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# USSR Report

MACHINE TOOLS AND METALWORKING EQUIPMENT

No. 8

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USSR REPORT  
MACHINE TOOLS AND METALWORKING EQUIPMENT

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## INDUSTRY PLANNING AND ECONOMICS

### ON INTENSIFYING PRODUCTION OF MACHINEBUILDING ENTERPRISES

Moscow PLANOVOYE KHOZYAYSTVO in Russian No 4, Apr 83 pp 101-106

[Article by G.Kulagin "Intensification: Ways and Means"]

[Text] The intensification of the economy presumes the rapid incorporation into production of the latest achievements of science and technology and better utilization of manpower and material resources. The realization of these goals demands for its part an accelerated rebuilding of the entire economic mechanism and planning system which took shape during the extensive growth period of public production and which, as evidenced by the past several years, are possessed of great inertia. The slow pace at which the reorganization of the economic mechanism was proceeding and the need to look for optimal methods in regulating the economy were pointed out at the November (1981) plenum of the CPSU Central Committee. At the November (1982) plenum of the Central Committee Secretary General Yu.V.Andropov reemphasized the urgent need to speed up work on improving the regulation and planning of the economy and the economic mechanism as a whole.

Of course, in the long-range perspective the primary instrument for raising production efficiency is scientific and technological progress. We must not, however, rely on its automatic character nor pin our hopes on it alone because, firstly, the renewal of basic producer facilities, now valued at over 1.3 trillion rubles, is a long process and requires vast sums of money, and, secondly, because even the most advanced technology does not produce the desired effect if its introduction is not preceded by appropriate organizational and economic measures.

Let us illustrate the above with two examples. Many plants and institutes have their own computer information centers with scores, sometimes even hundreds of employees, with electronic computers worth hundreds of thousands of rubles. Yet the real yield from this new technology is very modest if measured against capital expenditure. It would be difficult not to agree with academician Yu.E.Nesterikhin<sup>1</sup> who thinks that the incorporation

of computer technology into production is taking much too long, that, as a rule, computers have come to play the role of an expensive arithmometer and that in many plants computer information centers have turned from an effective weapon in the hands of managers and engineers into a new microdepartment with its own microinterests. In his opinion, the cause of this situation is the conservatism of industrial managers who to this day do not set much store on intellect and appreciate "only what you can pick up and hold in your hand".

It is not, however, the conservatism of management that is to blame, it is the fact that the extensive manufacture of large and expensive electronic computers was not paralleled by the timely production of peripheral equipment to gather and transmit basic data, by centralized software production, the creation of packets and libraries of typological programs, the unification of computer languages and the widespread training of engineers in the new mathematical skills. As a result, in designing automated control systems ministries, main administrations and even enterprises failed to coordinate their efforts. In our opinion, this is a sufficiently convincing example of how inattention to the organizational aspect devalues the effect of advanced technology.

Much has been written and said of late about the development of robots, the introduction of so-called peopleless technology. Some scientists and planners hold the view that in the very near future robots are likely to replace assemblymen and machine-tool operators, radically transform the machine-building industry and help overcome the current manpower deficit. All that is right. But you cannot hitch a robot to an all-purpose machine tool, their incorporation into the industrial process makes economic sense only in mass or conveyor production or in combination with program machine tools as elements in so-called versatile automated complexes. Each robotized section must perform the exact same duties every day or must be assigned a strictly defined and rather limited circle of operations within its capabilities. Any widespread use of robots and versatile automated production systems would require a fundamental reorganization of industry in the direction of more detailed and stabler specialization, widespread use of the group method of machining parts and bigger batches thereof, and, finally, a more dependable supply system. Consequently, in the given case also a compulsory prerequisite for the effective use of robots and program machine tools is the preliminary or at least the parallel resolution of management problems, otherwise the advanced technology will yield no return.

There are, furthermore, economic limitations to the introduction of new technology. The USSR has the world's largest park of me-

talworking equipment, including machine tools. Its annual renewal did not exceed 2-2.7%, with an increase of that figure to 4% only planned. It is not too difficult to figure out that the complete renewal of the currently active park will take place in 25 years, i.e after the year 2000.

But that is not all. Produced in 1981 were 205 thousand machine tools, of these no more than 10 thousand were equipped with digital program control, plus a mere 831 automatic and semiautomatic lines. And though the production of robots and manipulators is growing rapidly, even in 1982 it did not exceed 5.4 thousand units. Consequently, the newly-produced metal-working machinery consists for the most part of all-purpose machine tools and presses.

Many economists justifiably consider the machine-tool park too large and hold that it could be significantly reduced with active equipment being replaced by more advanced units. But this again calls for radical changes in the organization of production because about half the machine tool park is concentrated in repair shops and ancillary plants controlled by non-machine-building ministries where modern automatic lines, processing centers and robots cannot be utilized. Even in the basic machine-building industry the use of progressive equipment is economically feasible only if it carries a full workload, particularly an increase in the work shift coefficient which today stands at only 1.35. A modern machine tool with a digital program costs 3-4 times more than an all-purpose one and to cover its cost and maintenance must work 3 shifts a day. That is why the effective utilization of advanced machinery is possible only by increasing the level of specialization, expanding services provided by its manufacturers and creating conditions for multiple shift work.

Among the organizational and management problems on whose solution the intensification of production largely depends are, along with the redistribution of limited manpower resources in favor of the production sphere, the further improvement of the economic mechanism and planning system, an increase in the level of answerability on the part of production associations and plants for the mission entrusted to them and an end to the nit-picking guidance that hamstrings their initiative and enterprise.

At the November (1982) plenum of the CPSU Central Committee Yu.V.Andropov said: "It is necessary to create the kind of conditions, both economic and organizational, that would stimulate high-quality, productive labor, initiative and enterprise. And conversely, idleness and irresponsibility and bad work in general must in the most direct and relentless fashion affect the material rewards, job standing and moral prestige of the worker concerned." Yu.V.Andropov noted that the time has come for a practical approach to the matter of granting more independence



to production associations, plants, collective farms and state farms, but coupling it in all cases with increased responsibility and the protection of the people's interests.

In the mid-60s, when the author of this article was the director-general of the Leningrad Machine Tool Production Association imeni Ya.M.Sverdlov, the number of indicators in the annual plan subject to centralized affirmation was 8-10, at the present time it is over 20. To such indicators as volume of sales, products list, productivity, wage fund, profits and budget payments were added normative net output, production cost, number of employees, volume of top-quality products, reduction in manual labor, economy of materials and size of bonus funds. Unclear situations arise when it comes to evaluating accumulative fulfilment of the plan from the onset of the five-year period, with inevitable discrepancies cropping up in assessing normative net output, determining the volume of sales which remains the basis of money turnover, and in such important reporting indicators as profit, budget payments and enterprise fund size. The formation of bonus funds and the rules governing bonus payments to management have grown much more complicated inasmuch as the connection between the end result of the collective's endeavors and the size of the bonus funds has either vanished or is so involved as to be beyond comprehension not only for workers, but for plant management as well.

Practical experience has shown that increasing the number of approvable indicators and tightening control over the work of production associations (plants) often does not lead to better plan discipline but is conducive rather to the manipulation of individual indicators and provides plant managers with additional opportunities to cite objective reasons for lowering their target figures to the levels actually achieved. An overabundance of indicators limits management's initiative and its opportunities for maneuvering resources, engenders contradictions that hamper the growth of production efficiency and, in essence, removes responsibility for the end result from plant managers who not infrequently instead of resolving a problem on their own foist it on the shoulders of higher authorities. Here are several examples that confirm the above said.

Some time ago designers at the Leningrad Metalworking Plant proposed that the basic construction elements of hydroturbines be made of cheap welded metallostructures instead of costly steel castings. This proved beneficial to the plant, to consumers and to the state in that it reduced defective output, the production costs and the price of the turbines, raised profitability and eased pressure on critical facilities at supplier plants. However, the plant's productivity indicator took a sharp downturn because instead of simply processing the casting in the rough the work-piece now had to be cut, assembled and welded out of rolled metal sheets. The plant's management had to fight hard to have the

relevant indicators changed. Situations also arose that were directly opposite in character. The first processing centers had their ball screws, telescopic safety devices and feedback sensors made by the machine tool industry of Leningrad. The transfer of these elements' manufacture to specialized plants lowered the labor intensiveness of the centers and increased the proportion of purchased materials and ready-made assembly units in the finished product.

The transition to normative net output also does not solve every problem, in fact, it tends to breed some new ones. Evaluation by gross output encouraged management to use costly materials and look for more subcontracting, sometimes needlessly so, whereas now, especially if there are frequent changes in product assortment, normative net output may stimulate overestimation of the labor intensiveness of new products and thereby, with the overall picture seemingly good, make for a real reduction in norms and in the productivity of live labor.

Not always justified is the urge to increase the proportion of top-quality products in overall output. To award the Badge of Quality to a flatiron or a clothespin is, as has been pointed out time and again, a meaningless exercise. Let us dwell on another example. Not too long ago the machine tool industry of Leningrad was producing relatively simple and inexpensive milling machines which were in good demand here and abroad. Eventually they were pronounced obsolete and replaced by a much improved model with a greater measure of precision and speed, but the price went up several times. With the old machines still enjoying a good market, foreign buyers could not understand why their production had been terminated. They turned their backs on the new ones too, inasmuch as only a handful of consumers could utilize to the full the rich potential of the new machines, and anyway the price on them was too high.

To sum up: in real life economics the number and variety of situations that may arise is infinite, and to have them all covered by increasing the number of partial indicators is impossible. The only indicator that can serve as a yardstick for economic effectivity is the minimum aggregate expenditure of live and embodied labor per unit of economic effect and use value. Do any universal indicators exist that would induce different plants producing different goods to strive toward that minimum? Some economists think the answer is no. Yet exist they do, and used they are, but inconsistently and poorly. They are products list and price.

For the socialist state as the owner of the means of production and the upholder of the people's interests it would suffice to control the list of goods slated for production and their price which reflects the socially necessary input of labor per unit of

use value. Furthermore, the price can and must take into account the correlation between supply and demand, the scarcity or abundance of specific resources and the benefits for working people that stem from the social policies of a socialist state. Price is based on time norms that accord with the current level of productivity and unified rates and tariffs endorsed by state organs, and reflects the economic benefits reaped by society from putting the new technology into use.

Of course, to establish complete non-ministerial control over prices when the list of goods produced in the country runs into many millions is a very difficult proposition. A thorough check would have to be made of current rules and procedures, the agencies in charge of pricing would have to be reinforced, the sanctions imposed on violators of state decrees made harsher, the powers delegated to central and local pricing agencies re-examined, eliminating their subjection to local and ministerial pressures, the quality of material and financial balance sheets improved, greater maneuverability in the regulation of reserves achieved, and much, much more. Be that as it may, these problems are being tackled, though not quite satisfactorily.

The implementation of these tasks, above all the improvement of the pricing system, will influence all price-connected indicators: normative net output, production costs, productivity, wage norm per ruble of output, profits, economy of materials, and so on. How effectively each works will be known only when we succeed in regulating prices. With this in effect, the current system of planning the work of an industrial enterprise can be simplified, the centralized affirmation of a number of indicators gradually done away with, thereby freeing the central apparatus to tackle major long-term problems, plant initiative and socialist competition spurred and, finally, conditions can be established to protect the interests of the individual worker, the collective and society as a whole in equal measure.

To our mind, with the introduction of strict pricing controls (which, as a matter of fact, was not done under the economic reform of 1965) it would be expedient to endorse first and foremost the enterprise's planned sales list. As for profits, strict rules must be established to govern their allocation and utilization. We think it best to apportion profits in one invariable and very simple way -- before all else divide it into two parts, one earmarked for the budget and other centralized funds, the rest to remain at the disposal of the enterprise. Appropriate percentage tables can be used for this purpose with a guaranteed mandatory minimum of payments to the budget in the form of a capital charge, as is the case today. Out of the remainder of the profits the enterprise would be duty bound to pay off all fines outstanding for non-fulfilment of contractual obligations (the size of the

finances could well be increased), after which, again using strict normative tables, part of the remaining profits would be transferred to the enterprise development fund. The rest of the money must go into the bonus and the social development funds of the enterprise. In due course these funds, along with rising individual productivity, can become the primary source of growth in working people's money income and living standards.

All these ideas and possibilities were contained in the reform of 1965 and in the CPSU Central Committee decree of July 12, 1979 on improving the economic mechanism. In the first instance, however, they were not implemented because of weak control over prices and an unwarranted growth in enterprises' profits, in the second because the resolutions adopted, as mentioned earlier, are being carried out too slowly.

To our mind, the normative figures for dividing profits between the state and the enterprise, as well as for the latter's share for its production development and bonus funds, may be determined to apply to conditions prevailing to a cost-accounting plant, but it is imperative that they be long-term in character, stay in effect for a minimum of five, perhaps even ten years, and carry the power of law which no one be allowed to break. Only if these conditions are observed can industrial, party and labor union leaders really mobilize their collectives to up the effectivity of production.

Along with part of the profits the enterprise's production development fund must, we think, take in its amortization deductions, and in larger sums than today. The plant director can accept full responsibility for the job entrusted to him only if he controls the funds required not only to keep current production going, but to re-equip and reconstruct the enterprise as well because with the ongoing scientific and technological revolution both measures are a continuous, not a one-time, undertaking. As long as the renewal of the means of production depends mainly on centralized financing the plant director cannot, and in fact does not, carry responsibility for full renewal, advanced technology, better working conditions and compliance with demands laid down by state inspection teams. To achieve intensification of production enterprises must be charged with greater responsibility for their own development in order that budget and other centralized allocations be used primarily to create new production units, develop the infrastructure and, in cases when functioning enterprises are ordered to switch to completely new products, to reconstruct and expand.

The same enterprise development fund can also be used to finance the designing and readying for production of new commodities in line with the plant's permanent product assortment. State and other centralized sources of financial allocations for these purposes should, in our opinion, be utilized only if the item is absolutely new in principle and if its manufacture is based on

the pioneering incorporation into production of the most up-to-date scientific discoveries.

Mention must be made of another significant aspect of the problem. If the growth of money income and other benefits for production workers comes to depend on the size of bonus funds earned by their own toil, if, in other words, there is a sharp upswing in the role played by collective forms of material incentives and by social factors, it will undoubtedly make for more cohesion in the collective, reduction in manpower turnover, stronger discipline, the active participation of each worker in seeking out reserves and running the affairs of the enterprise and, in the final analysis, for the formation of a communist world outlook.

No less important than the selection of a system of indicators are these questions: how do you work out an optimal plan for an enterprise and how do you assess its fulfilment? Many production people blame all shortcomings on plans based on levels achieved. But the level achieved has always been and will continue to be the realistic base upon which any planning process is built. It is not here, in our opinion, that the answer lies, it is in arbitrary additions to that level and to the plant performance evaluation system, additions not backed by strict calculations or real resources. This is the main reason why all managers strive to get as small a plan as possible.

At the present time some economists place high hopes on restructuring the planning system and enterprise performance evaluation by basing both on mean industry-wide norms. For some plants, however, this would solve nothing. Such an evaluation is justifiable when similar production conditions prevail, namely -- similar equipment, technology and raw materials quality. This requirement is more or less met by textile factories, milk plants, sugar mills and analogous enterprises which put out one and the same product year in, year out. On the other hand, the idea is inapplicable to the extractive and metallurgical industries which function in different natural and geological environments and use different quality prime materials and different technologies.

In our opinion, for the problems discussed above to be resolved it is imperative that we put an end to arbitrary methods of planning and base all plans on sober engineering and economic estimates. Effectivity should be measured by the growth achieved in the output of goods endorsed for production (if there are no limitations in sales or raw materials) and by profit.

Strict sanctions should be introduced and management punished only if the enterprise ends up at the preceding year's level or goes below it. Exceeding that level should be stimulated by, among other things, the progressive growth of its bonus funds and an increase in bonus payments to top-ranking personnel. Any "adjust-

ments" in plans, for whatever reason, are impermissible because that would knock all coordination between them out of line.

Speaking of plan coordination, its real-term basis must be the preceding year's level. All accretions to that level can serve as the prime source for the creation and expansion of a system of state reserves without which we are unlikely to ever rid ourselves of breaks in supply, work stoppages and production irregularity, the main causes of production losses. The established routine, when all or almost all of the planned output goes into distribution, by no means guarantees its delivery, a fact witnessed to by constant plan adjustments which not only undermine the original coordination but also exert a pernicious influence on plan discipline in general.

A brief word on material supply. Industry cannot function without reserves, and these must be accessible to planning and distribution organs. At the present time reserves are dispersed, stored mainly in the warehouses of consumer plants and therefore unusable for maneuvering. For example, in late 1982 the Leningrad production association "Istochnik" experienced great difficulty in meeting its target figure for the production of accumulators because it lacked a few dozen tons of lead, while at the same time hundreds of tons of the metal were lying idle at the nearby production association "Sevkabel" ".

What is needed, therefore, is a radical change in the situation: reserves must, as a rule, be located in the warehouses of producer plants or at wholesale bases of the State Committee for Material and Technical Supply (Gossnab). Of course, a metallurgical combine cannot function without due reserves of ore and coking coal which it must replenish through its ongoing ties with quarry and mine. With most machine-building enterprises, however, it is a different story in that they consume hundreds and thousands of type sizes of rolled metal, chemicals, paints, wires, bearings, etc. in relatively small amounts and continuously changing proportions. Similar situations often arise in the shoe and garment industries which must keep up with ever-changing tastes in fashion. Research institutes and design bureaus suffer even more, inasmuch as their needs are extremely diverse and unpredictable and the amounts required are infinitesimal.

In all these numerous instances direct links with the supplier will not do the job. Neither will increasing orders to the level of so-called transit norms because, on the one hand, it is not enough to provide the producer's facilities with an optimal workload and, on the other, creates unwanted surpluses at consumer plants and contrived shortages in the general scheme of things.

A tried and true method of radically improving supply and increasing the mobility of available resources does exist. It boils

down to the comprehensive development of the warehouse form of supply by the Gossnab system of territorial organs and and an end once and for all to further fragmentation of reserves among numerous ministries and departments.

Mass materials and general purpose goods such as metal, chemicals, paints, bearings, nuts and bolts and the like can be ordered with producers and shipped to consumers through the wholesale bases of Gossnab. This will allow to enlarge orders and thereby better utilize producer facilities; to sort, cut and package materials into small lots to comply with consumer needs; vastly reduce the number of active contractual ties and correspondingly the amount of paperwork and railroad shipments; greatly increase the dependability of supply and the maneuverability of resources on hand. The advantages of this form of supply have long been proved by experience. For example, on the initiative of the Ministry of the Machine Tool and Tool Building Industry and the main territorial office of Gossnab a metal-sorting base was organized in Leningrad to handle the rather modest task of supplying the small group of local machine-tool producers with construction rolled metal. Notwithstanding its very limited scope, this measure brought about a marked improvement of supply and a reduction in total reserves in plant warehouses and the base itself.

Another measure necessary for the intensification of the economy is to accelerate the creation of production associations with the full inclusion therein of design bureaus and institutes engaged in the development of concrete scientific themes and to ensure thereby that the economic interests of the developers and the producers coincide. Efforts must be made to extend the scope of specialization, above all to create highly specialized and automated enterprises to produce general-purpose goods, semi-finished pieces and mass tools. A very important step would be the redistribution of manpower in favor of the production sphere by way of reforming the education system and reducing the workforce in some sectors of the non-production sphere. Apparently inevitable are some changes in the structure of the central apparatus running the economy. It would be very helpful to precisely define the rights and obligations of a socialist enterprise, allowing it enough leeway to maneuver all its resources and charging it with full and complete accountability for the end result of its endeavors.

#### FOOTNOTES

1. Yu.E.Nesterikhin, "Vychislitel'naya Tekhnika: vozmozhnosti i bar'yery" /Computer Technology: possibilities and barriers/ "EKO", 1982, no 10
2. "Materialy Plenuma Tsentral'nogo Komiteta KPSS" /Materials on

the CPSU Central Committee Plenum of Nov 22, 1982/ Moscow, Polit-  
izdat, 1982, p 9

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## INDUSTRY PLANNING AND ECONOMICS

### BRIEFS

SEEING ROBOT--In a shop at the bureau of technical cibernetics of the Leningrad Polytechnical Institute imeni M. I. Kalinin the assembly of a robot is progressing. For the first time in the history of Soviet robot technology, the manipulator will have vision: it will be able to distinguish objects by their configuration. When such a robot is given a program to select gears or pinions from a mass of parts, it will never grasp a bolt or nut with its four "fingers." Its technological "eye" will be built analogously to a human eye, but the role of the retina will be fulfilled by a television camera. The role of the brain cortex will be played by a central processor that will help the robot to analyze entering signals and recognize the item. There is a wide range of applications for a robot with technical vision, but the most proximate area for its application is that of parts sorting. /Text/ /Yerevan PROMYSHLENNOST' ARMENII in Russian No 12, Dec 82 p 65/ 12131

AUTOMATED BORING MACHINES--Charentsavan, Armenia--Boring machines with numerically controlled parts with high accuracy. The machines are being produced by the Charentsavan Machine Tool Plant. A special device makes it possible to produce artifacts of various configurations, including conic shapes. The first of the new machines is earmarked for automobile plants in Byelorussia. /Text/ /Moscow KRASNAYA ZVEZDA in Russian 14 Jan 83 p 1/ 12131

SPECIAL METAL PROCESSOR--This "iron" master craftsman with remarkable capabilities, named by the automated metal processing center, has been established in the "Kalininmashdetal'" association. It can replace a wide range of various machine tools. The "warehouse" of the combine includes 30 different tools. At computer command the tools needed for a particular job will be put into operation. In a matter of minutes, a roughly shaped casting can be made into complex components. The computer not only controls the process, but also permits the operator to see a display on a screen that shows the operation of the individual instruments and the entire system. /By R. Bikmukhametov, special correspondent, IZVESTIYA, Kalinin/ /Text/ /Moscow IZVESTIYA in Russian 21 Feb 83 p 1/ 12131

ASSEMBLY ROBOT--No people will be seen on many of the assembly lines in the workshops of the Saran Instrument Making Factory. The first step toward introducing industrial robots and manipulators at the plant was taken at the beginning of last year, when the robot design bureau appeared here. Now there are entire robotized complexes and sections. For example, shop No 7 has seen the entire task of stamping operations transferred to the "shoulders" of robots, while the

sixth shop has seen manual labor replaced by four automated lines with wide application of technology in the assembly of complex instruments. There are now 28 robots and manipulators at work in the plant. By the end of the 11th Five-Year Plan their number will grow to 110. The volume of production will grow by 30 percent with no increase in the number of employees, and the level of mechanization will surpass 70 percent. /Text/ /Moscow SOVETSKAYA ROSSIYA in Russian 6 Feb 83 p 1/ 12131

MINISTER OF HOUSING AND MUNICIPAL SERVICES--The Presidium of the RSFSR Supreme Soviet has appointed Filipp Vasilyevich Popov as RSFSR Minister of Housing and Municipal Services, releasing Sergey Mikhaylovich Butusov from these duties in connection with his retirement. /Text/ /Moscow SOVETSKAYA ROSSIYA in Russian 3 Feb 83 p 1/ 12131

HOT STAMPING PRESS IN UDMURTIA--A hot stamping automation line has been put into operation in the forging and stamping shop of the "Izhmash" association in Udmurtia. /Text/ /Moscow EKONOMICHESKAYA GAZETA in Russian No 14, Apr 83 p 3/12131

INCREASING ROBOT NUMBERS--The Mogilev Test and Experimental Plant for Automation and Mechanization is a specialized enterprise for producing nonstandardized equipment and devices for machinebuilding for animal husbandry and feed production. Recently this plant has become famous as a robot technology producer as well. Here tests are conducted of prototypes of industrial robots for sheet stamping components with 25-160 tons of stamping pressure. Man's mechanical helper has high productivity, being able to complete 15-30 work cycles per minute. Two mechanical arms place rough castings onto the press with great precision, up to .25 meters, check the accuracy of placement, monitor the removal of the finished product, and make sure there are no double press operations. In all of these operations no more than 0.6 kwh of power is used. Now technologists, designers and workers at the plant are preparing for full production of these robots. In the 11th Five-Year Plan, the plant will begin production of two more types of sheet-metal-working robots, for presses of 250-1000 tons pressure, as well as manipulators for automatic painting of external surfaces, robots for mechanized loading of metal cutting machinery with numerical control, and welding equipment. /By A. Galinovskiy, senior engineer, Mogilev Oblast Laboratory of State Supervision of Standards and Measurements/ /Text/ /Minsk SOVETSKAYA BYELORUSSIYA 5 Feb 83 p 2/ 12131

CIRCULAR WEAVING MACHINES--Ivanovo--The circular weaving machines whose series production was developed at the Shuyskiy Machinebuilding Plant imeni M. V. Frunze are distinguished by their efficiency. Thanks to the original design, the machines are half as heavy but have twice the productivity of current models. They will be supplied to weaving textile plants that prepare synthetic fibers for technical purposes. /Text/ /Kishinev SOVETSKAYA MOLDAVIYA in Russian 23 Feb 83 p 1/ 12131

MICRON MEASURING EQUIPMENT--Leningrad--A brigade of experienced machinists can be replaced by the unit "lathe center" made by the Ya. M. Sverdlovsk Association. Series production has begun of such automatic equipment, supplied with devices for numerical control. It is intended for small-run production of complex components used in the aviation and automobile industry and instrument making. This novelty is nearly three times as productive as existing equipment intended

for similar applications. The production of high-precision equipment is one of the basic directions in the plant's specialization. Along with large machinery capable of boring multi-ton components, and powerful processing systems, the plant has also created a gamut of new generation "jewelers." /Text/ /Moscow KRASNAYA AVEZDA in Russian 20 Mar 83 p 1/ 12131

POSTAL ROBOTS--Akhtyrka, Sumsкая oblast --The series production of machines beginning at the Akhtyrka "Promsvyaz'" Plant will ease the work of postal employees. The package-typing assemblies will not use metal bands, permitting annual savings of 2 tons of expensive carbon steel. This year Soviet post offices will receive 200 such automatic wrapping machines. /Text/ /Kishinev SOVETSKAYA MOLDAVIYA in Russian 22 Mar 83 p 1/ 12131

'STRELA' PICKS UP SPEED--Oknitsa, Moldavia (TASS) Mar 23--The "Strela" will cut rolled metal considerably faster now. The "Strela" is a plasma cutting machine serially produced by the Oknitsa Test Plant for Technological Equipment. The factory complex is using a new plasmatron that increased the equipment's productivity by a factor of 1.5 and expanded the range of its applications. The improved "Strela" will easily deal with steel plate of 150mm thickness. Products will be produced under the guidance of a photoelectric device that reads drawings and is distinguished by its high precision. Metal waste will also be reduced by the highly precise and clean cutting, which requires an insignificant amount of polishing. Thus the "Strela" machine for plasma cutting promises improved production in all regards. /Text/ /Moscow PRAVDA in Russian 24 Mar 83 p 2/ 12131

WORKING CONDITIONS, SAFETY--[In response to the review in EKONOMICHESKAYA GAZETA, No 7] The review correctly directed the attention of the Ministry of the Machine Tool and Tool Building Industry to reducing the "noise level" of forging press equipment and woodworking machinery. The main institutes of the branch, in conjunction with specialized associations and factories and labor safety scientific research institutes, have now developed the most effective means for assuring noise- and vibration-abatement in the working place. These include hydraulic presses, automatic thermoplastic equipment, stamping machines and mechanical presses. Research is being continued on devices for vibration dampening for mechanical press components. These most important developments permit the creation of more comfortable conditions for operators in forging and stamping production. The Voronezh "Tyazhmekhpess" Production Association will implement the development and production of automated complexes supplied with manipulators and automated gripping devices in the current 5-year plan, according to its new technology plans. At the same time, it will produce original manipulators for servicing heavy hot-stamping presses. Measures are being taken to increase the technical level of woodworking equipment and for further improvement in working conditions and safety in this occupation. So far the experimental-design organizations have prepared technical documentation for four-side planers (three models), trimming saws (two models), joiners and scribes, as well as automation lines supplied with sound-insulating barriers that reduce noise to permissible levels. By A. Vasil'yev, USSR deputy minister of Machine Tool and Tool Building Industry. /Text/ /Moscow EKONOMICHESKAYA GAZETA in Russian No 17, Apr 83 p 1/ 12131

## AUTOMATED LINES AND AGGREGATE MACHINING EQUIPMENT

### AUTOMATION'S ROLE IN HEATING TECHNOLOGY IMPROVEMENTS DISCUSSED

#### Systems Approach to Normal Fuel Consumption

Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 11, Nov 82 pp 29-33

[Article by G. G. Nemzer, I. K. Enno, M. A. Aronov and I. Ye. Molochnikov:  
"A Systems Approach to Norming Heat Consumption by Heating and Heat Treating  
Furnace Bays"]

[Text] The elaboration and introduction into practice of scientifically based fuel consumption rates for heating and heat treating furnaces and the organization of effective control over their fulfillment are essential conditions for improving the efficiency of fuel consumption in producing large forgings. At present, under the conditions of short-series and individual production of large forgings, fuel consumption by the furnace bays is determined extremely tentatively: in designing based on consolidated standards given in the references [1, 2] in the form of proportional expenditures per unit of furnace bottom area or the weight of the products treated in it; during operations on the basis of proportional fuel consumption obtained proceeding from the average data for the sector and which under the specific conditions are adjusted in the process of acquiring production experience.

The basic shortcomings of the employed methods of norming fuel consumption consist primarily in the fact that they do not consider the existing features of real production in terms of the range of products to be worked, the production methods, the furnace equipment and the adopted controls of its work; in addition, they also do not encourage greater heat utilization efficiency. The structure of the furnace system of press forging and heat treating shops and the range of articles and methods employed for their heat treating are very complex and diverse and at the present stage require a systems approach in determining the fuel consumption rates. The necessity of revising the methods for fuel consumption norming involves not only a strengthening of fuel consumption discipline. Such measures as improving furnace designs and the realization of progressive heating conditions for working the metal and new methods for controlling the work of the heating and heat treating equipment demand an accurate calculation and differentiated assessment of their contribution to increasing heating efficiency.

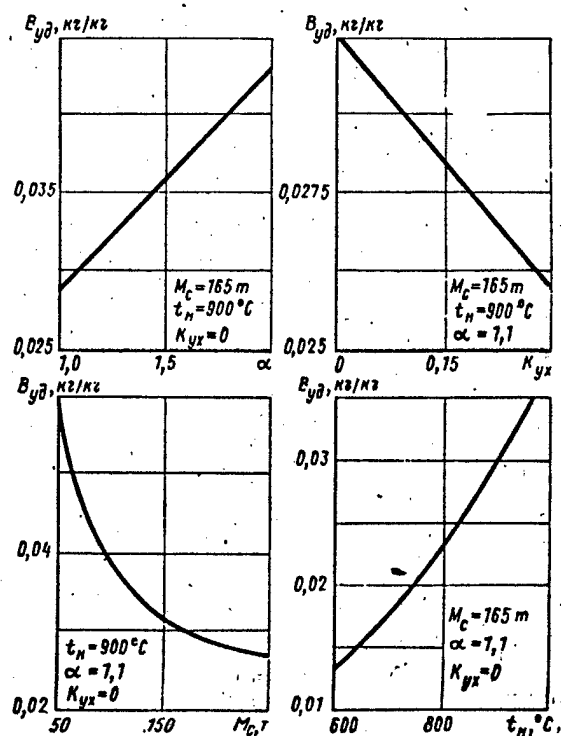


Fig. 1

cant number of technical and production factors. Among the first group of factors are the parameters of the furnace--charge system (its geometric characteristics, thermophysical properties, heat exchange characteristics, type of fuel, the nature of its combustion and so forth). In the second are the parameters of the heating conditions realized in the furnaces (temperature and rate of heating, the length of the isothermal heating periods). As specially performed calculations have shown, all the technical and production factors have a substantial impact on furnace fuel consumption. Fig. 1, as an example, gives the calculated dependences of the specific consumption of fuel units upon the weight of the charge ( $M_c$ ), the coefficients of air consumption ( $\alpha$ ) and heat recovery  $K_{yx}$ , and a heating temperature for a heat treating furnace with a characteristic bottom size of  $4 \times 10 \text{ m}$  and a lining from fibrous refractories. Metal heating conditions are examined from 200 to 600, 800 and  $1,000^\circ\text{C}$ . Obviously a change in the actual limits of the designated factors will lead to a change in the specific fuel consumption from 26 to 280 percent. As a whole, as follows from the calculated analysis, a change in the technical and production factors within a realistic range can change specific fuel consumption by 2-3-fold within one production cycle.

The heating and heat treating furnace bays with individual and small series production of large forgings are stochastic systems [3] and consequently the values of many of the technical and production factors (for example, the weight and shape of the charge, the temperature and speed heating) are in the strict sense of the word random values. The parameters for the distribution laws of these values are determined by the rules for the loading of the furnace equipment and the adopted control for its operation. The advanced nature of the

Up to the present, a detailed analysis of furnace fuel consumption has been impeded by the necessity of realizing a comprehensive approach which includes mathematical modeling of the various heat processes and the operating conditions of the furnace equipment as well as the use of extensive experimental and statistical information on annual production. At present, the VNIPTeploproyekt [All-Union Scientific Research and Design Institute for Thermal Engineering] has acquired definite experience in achieving such an approach to studying the thermal processes involved in producing large forgings [3]. This experience has made it possible to work out the prerequisites for creating new fuel consumption rates and for determining a rational discipline for fuel utilization.

In solving the given problem, it is essential to surmount the complexity of the fuel consumption structure in press forging and heat treating shops. Furnace heat consumption depends upon a signifi-

functioning modes of furnace equipment can be expressed quantitatively through coefficients of furnace utilization in terms of tonnage, time and so forth and these characterize the effectiveness of operational planning for the work of the furnace bays.

The control factors along with the technical and production factors substantially influence fuel consumption. For example, with an unsatisfactory mode for receiving hot ingots from the steel casting shop by the press forging shop, these can cool down before loading in the heating furnaces or in the forehearth to the "warm" or even "cold" categories [3]. Here, as calculations indicate, a reduction in their average mass temperature from 800-900° C by every 100° C leads to an increase in specific fuel consumption by ~5-8 percent in heating for forging. Due to ineffective control over the heating division, to ensure the continuous operation of the press equipment, the ingots and forgings are heated to forging temperature often simultaneously in several heating furnaces. This measure makes it easier to plan the work of the heating division by creating a supply of hot metal, but sharply reduces fuel utilization efficiency. As calculations show, each surplus hour of holding the ingots or forgings at a temperature close to forging increases specific heat consumption by ~1-2 percent. The load factor of the heating and heat treating furnaces also has a substantial impact on fuel consumption.

An analysis of the complex structure of fuel consumption by the furnace bays in the press forging and heat treating shops indicates that from the practical standpoint there are no minor details in increasing the thermal efficiency of the heating and heat treating equipment and all the elements of the system are interconnected and are of substantial significance. Under these conditions greater effectiveness of fuel consumption is possible only by realizing a special comprehensive program (the "fuel" program) and the current work is devoted to the creation of this. Fig. 2 gives the basic tasks to be solved within the "fuel" program. These can be divided into three groups which differ in the varying degree of essential detailing in calculating the listed factors: the organization of fuel norming in existing production, the forecasting of fuel consumption by furnace bays being designed and the elaboration of consolidated fuel consumption rates by the furnace bays. The carrying out of this program for each of the designated areas requires the processing of large amounts of information on actual fuel consumption and the carrying out of labor-intensive calculations to model the heating and organizational processes. If one also considers the task of collecting and processing the statistical information, it can be concluded that the "fuel" program should be based upon the use of modern high-speed computers.

The group of problems the solution to which involves current production is the most complicated since it is essential to have a high level of detailing in considering the factors which influence fuel consumption.

In this instance, there must be not only the creation of a method for norming fuel consumption and its program support, but also the carrying out of a large amount of work to create a subsystem of enterprise ASU [automatic control system] "norming and accounting of fuel consumption" (NUT) and preparing production for its introduction (see Fig. 2). Considering that a significant effect can be obtained in carrying out a portion of the tasks in this group, it is

# 1. Задачи нормирования и анализа топливотреблений (создание системы "топливо")

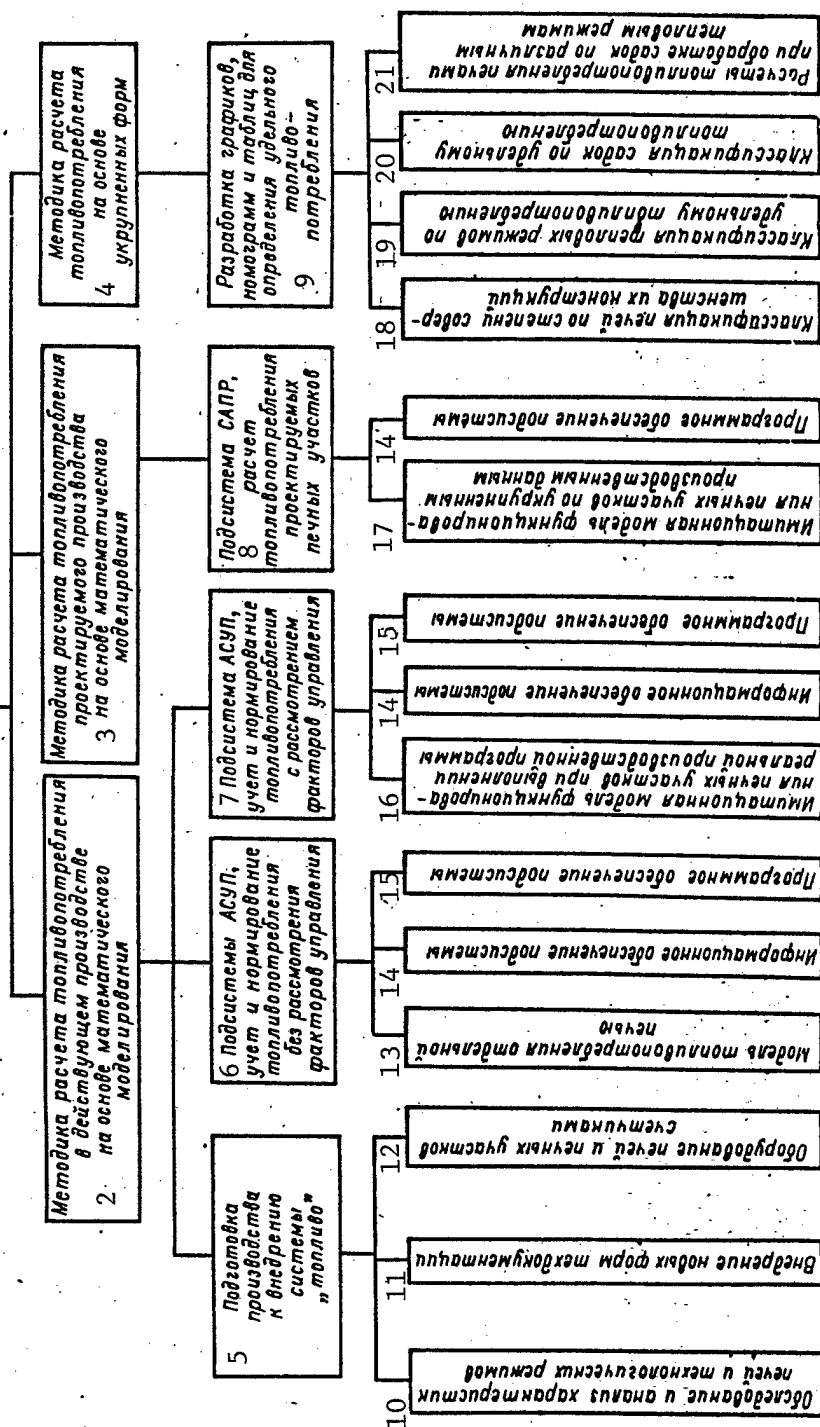


Fig. 2

Legend: 1--Tasks of norming and analyzing fuel consumption (creation of "fuel" system); 2--Method of calculating fuel consumption in current production on basis of mathematical modeling; 3--Method of calculating fuel consumption for designed production on basis of mathematical modeling; 4--Method of calculating fuel consumption on basis of consolidated forms; 5--Preparation of production for introducing "fuel" system; 6--Subsystems of ASUP [automated production control system], accounting and norming of fuel consumption without examination of control factors; 7--ASUP subsystem, calculation of fuel consumption for furnace bays being aiming of control factor; 8--SAPR [?automatic design system] subsystem, calculation of fuel consumption for furnace bays being designed; 9--Elaboration of graphs, nomograms and tables for determining specific fuel consumption; 10--Investigation and analysis of furnace performance and production conditions; 11--Introduction of new technical documentation forms; 12--Equipping furnaces and furnace bays with meters; 13--Model of fuel consumption by individual furnace; 14--Information support for subsystem; 15--Program support for subsystem; 16--Simulation model for functioning of furnace bays according to consolidated production data; 18--Classification of furnaces according to progressiveness of their design; 19--Classification of heating conditions according to specific fuel consumption; 20--Classification of charges by specific fuel consumption; 21--Calculations of fuel consumption by furnaces in treating charges using various heating conditions.

advisable as a prerequisite to examine the following two-stage approach to creating and introducing new fuel consumption standards for furnace bays in current production.

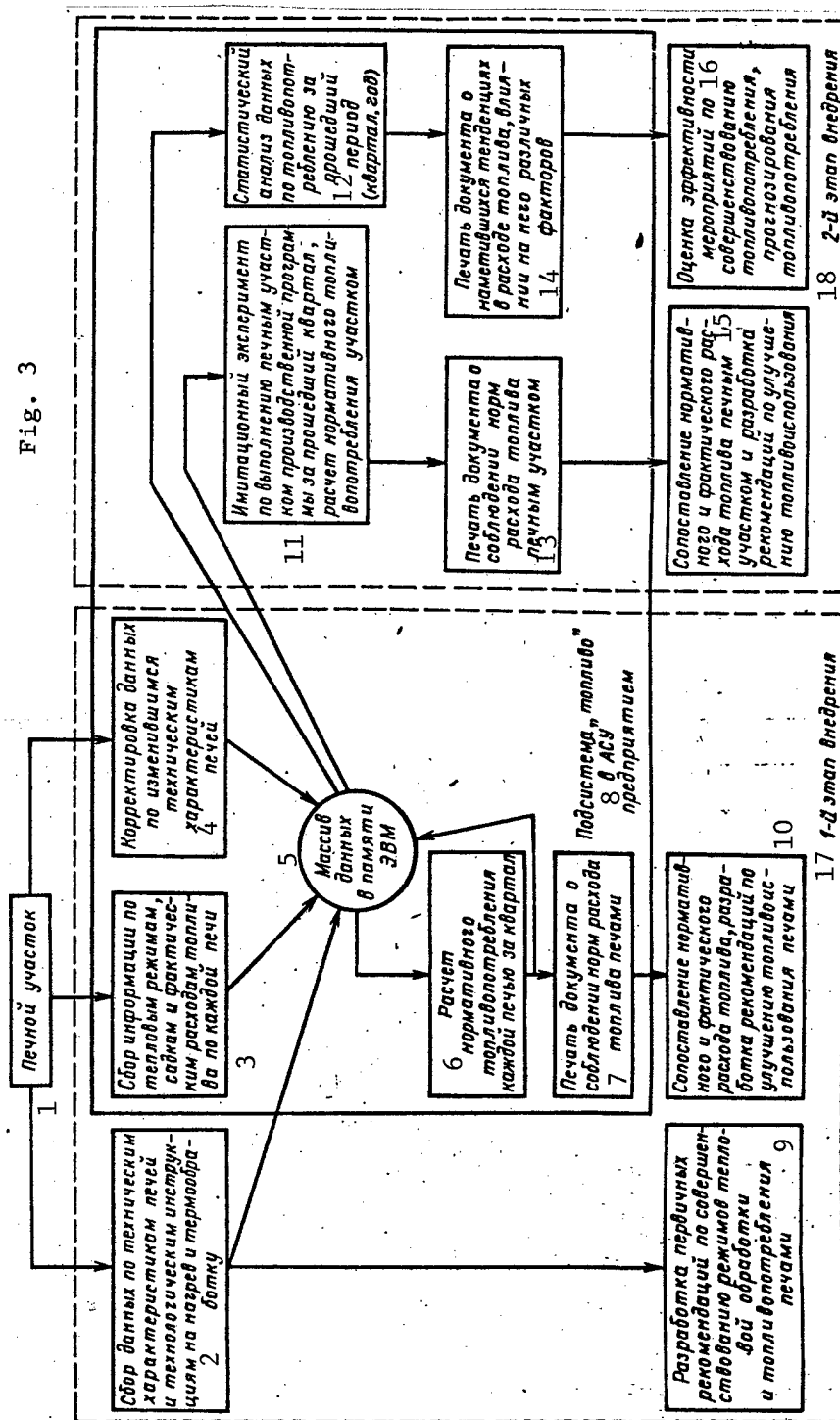
During the first stage of setting up the NUT system, particular attention should be given to production preparation which includes: inspecting the furnace system; equipping the furnaces with fuel meters; introducing a special form of technical documents for fuel consumption accounting. The examination of the furnace system consists in determining the heat engineering performance of the furnaces and the level of their operation, an analysis of the employed heating conditions and the existing production discipline. From the results of the survey, primary recommendations are drawn up to improve furnace fuel consumption. In addition to this, within the given stage, a standard method is worked out for calculating normed fuel consumption by an individual furnace with fixed values of the technical and production factors, that is, a somewhat simplified approach is realized whereby the questions of the influence of the control factors on fuel consumption are not taken up.

In the second stage, a comprehensive approach is employed which examines the fuel consumption of the bay as a whole and considers the random nature of the technical and production factors. The task is posed thus when it is essential to determine the normed fuel consumption for a furnace bay being designed or an actual one, but not with the existing but rather a different, more efficient control. Calculating fuel consumption here comes down to finding the laws for the distribution of the technical and production factors which have a random nature for each furnace in a bay, and primarily their average values. Then the bay's fuel consumption is determined from the designated simplified scheme.

Let us examine in greater detail the practical possibilities of carrying out the designated two approaches. A standard method for calculating furnace fuel consumption has presently been set up at the VNIPITeploproyekt in terms of the class of heating and heat treating furnaces with an evenly distributed type of heat exchange in the melting space. In this class is a majority of the fired box car-type furnaces operating at the machine building plants, in particular, furnaces equipped with the GNP and GTPTs type of burners. The method is based upon an analysis of the furnace's fuel balance equation. The individual components of this equation are determined by the combined solving of equations for the external radiant convective and internal conductive heat exchange in the furnace with its set temperature conditions and with a simplified understanding of the compound charge in the form of an equivalent slab or cylinder. Specially performed calculations using the procedure outlined in the work [4] and considering the geometry of the charge in calculating heat exchange have confirmed the possibility of replacing such a compound charge in determining fuel consumption. Using this program with an error factor of not more than 5 percent, furnace fuel consumption is determined depending upon the following parameters: the weight of the charge and its characteristic dimension, the thermophysical properties of the steel, the dimensions of the furnace melting chamber, the design of the lining (the thickness of its individual elements and their thermophysical properties), the heating value of the fuel, the coefficients for air consumption and heat recovery, the circulation factor for gases in the working volume, the initial and final heating temperatures, the temperature values and the length of isothermal heating as well as the rate of



Fig. 3



Legend: 1--Furnace bay; 2--Collection of data on furnace performance and technical instructions for heating and heat treating; 3--Collection of information on thermal conditions, charges and actual fuel expenditure for each furnace; 4--Adjustment of data for altered furnace performance; 5--Data file in computer memory; 6--Calculation of normed fuel consumption for each furnace over the quarter; 7--Printing of document on the observance of fuel consumption standard by furnaces; 8--"Fuel" subsystem of enterprise ASU; 9--Working out of primary recommendations to improve conditions for heat treating and fuel consumption by furnaces; 10--Comparison of normed and actual fuel consumption, working out of recommendations to improve furnace fuel consumption; 11--Simulation experiment for the fulfillment of production program by the furnace bay over the previous quarter, calculating normed fuel consumption by the bay; 12--Statistical analysis of fuel consumption data for previous period (quarter, year); 13--Printing of document on observance of fuel consumption standards by furnace bay; 14--Printing of document on noted trends in fuel consumption and influence of various factors on it; 15--Comparison of normed and actual fuel consumption by furnace bay and working out of recommendations to improve fuel consumption; 16--Assessing effectiveness of measures to improve fuel consumption and forecast it; 17--First introduction stage; 18--Second introduction stage.

heating. The program for carrying out the given method on a YeS type computer is characterized by simplicity of preparing the initial data and an insignificant calculating time (usually not more than a minute on the YeS-1050).

Considering that in recent years industry has more and more widely employed furnaces equipped with various designs of batwing and high-speed burners, that is, correspondingly with an oblique radiant and directed radiant type of heat exchange, at present analogous methods are being worked out to calculate fuel consumption for these types of units.

The method for determining the control factors is based upon the employment of the simulation modeling method. The VNIPITeploproyekt has acquired definite experience in working out and utilizing simulation models oriented at analyzing the capacity and load factor for equipment in furnace bays. The use of such models for analyzing fuel consumption requires a more detailed elaboration in them of questions involved in controlling the work of the bays and this is presently being carried out.

By a simulation model for the functioning of furnace bays one understands here a computer program in which all the basic time-space relationships between the equipment and the material flows of metal in the bay are realized in the form of the functional relationships between the program's variables [5]. Input into the model as the initial data are the composition and technical characteristics of the bay's equipment, the production program (the range and working conditions), as well as the basic principles for controlling the operation of equipment. This makes it possible to test out on the model different variations of control algorithms for the furnace bays, automatically determining the technical and economic indicators for their operation in so doing. In this manner it is possible to obtain the average statistical data essential for calculating fuel consumption and a variation of control whereby highly efficient fuel utilization is attained.

The control principles incorporated in the simulation model are a formalization of the shop personnel's management activities. The present state of this question is such that any effective algorithms function on the level of a middle-skill dispatcher. For this reason, the efficient use of fuel achieved in the simulation model can be viewed as the lower limit the violating of which shows poor quality control of the furnace bay from the standpoint of fuel utilization. We would point out that in the event of group, series production of forgings, it is possible not to resort to a computerized simulation model, but rather organize control for carrying out the entire production program in the form of a cyclogram for the combined work of the furnace and press equipment from which the values of the necessary factors are then determined.

The introduction of the proposed method for norming fuel consumption into the actual work of the press forging and heat treating shops should also be carried out in two stages: in the first fuel consumption norming should be organized on the level of a simplified approach and then in the second on the basis of a comprehensive one. Fig. 3 gives a block diagram for the functioning of the "fuel" system for the furnace bays of press forging and heat treating shops involved in small-series production. The diagram shows both indicated stages of introduction, it gives the sequence of measures in the functioning of the "fuel" system and indicates the information flows in it.

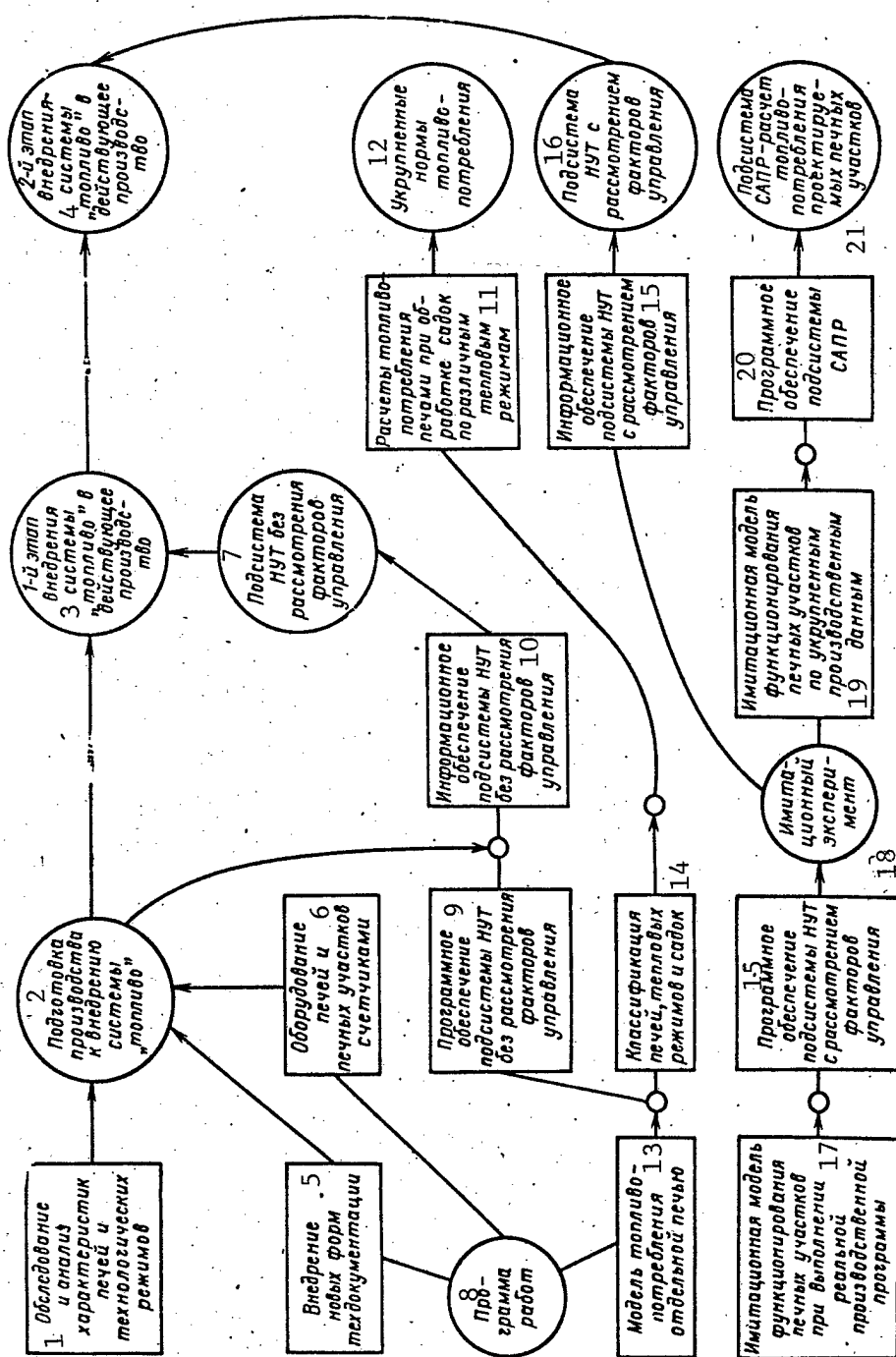


Fig. 4

Key: 1--Examination and analysis of furnace performance and production condition; 2--Production preparations for introducing "fuel" system; 3--First stage of introducing "fuel" system in current production; 4--Second stage of introducing "fuel" system in current production; 5--Introduction of new technical document forms; 6--Equipping furnaces and furnace bays with meters; 7--NUT subsystem without examination of control factor; 8--Work program; 9--Program support of NUT subsystem without examination of control factor; 10--Information support of NUT subsystem without examination of control factor; 11--Calculations of fuel consumption standards; 13--Fuel consumption model for individual furnace; 14--Classification of furnaces, thermal conditions and charges; 15--Information support of NUT subsystem with examination of control factor; 16--NUT subsystem with examination of control factors; 17--Simulation model for functioning of furnace bays in carrying out real production program; 18--Simulation experiment; 19--Simulation model for functioning of furnace bays according to consolidated production data; 20--Program support of SAPR subsystem; 21--SAPR subsystem--calculation of fuel consumption for furnace bays being designed.

The normed value of fuel consumption is figured for each furnace of the bay at the end of a certain period of time, for example, a quarter, using the actual data for the treated charges and set thermal conditions. If the value of fuel consumption according to the meter readings exceeds the calculated normed one by not more than 10 percent, from the viewpoint of fuel consumption it can be considered that the furnace is operating satisfactorily. Otherwise, there is a fuel overconsumption which shows the unsatisfactory technical state of the furnace or its incorrect use. With a subsystem for the operational collection of information on the operation of the furnace bays as part of the ASUP, it is advisable to incorporate in it data transmission for fuel consumption. The basic result from the first stage of introducing the new method for norming fuel consumption by the furnace bays is increased efficiency in fuel utilization by improving furnace operations, systematizing the monitoring of fuel consumption in them and the possibility of routine analysis of the efficiency of the thermal conditions.

In the second stage of introducing the method for norming fuel consumption, a program for simulating the operation of the heating and heat treating furnaces is incorporated in the appropriate subsystem of the ASUP. Using this program, one can determine the factors for controlling the furnace bay which are optimum from the viewpoint of its fuel utilization. Then fuel consumption by the furnace bay corresponding to optimum control is calculated and then compared with actual fuel consumption. Thus, the given stage of introduction makes it possible to monitor not only the thermal operation of the individual furnaces, but also the effectiveness of control over the entire bay as a whole. The possibilities of a simulation model do not end with this. It is possible to substitute in it as initial data the production program for a future plan period and by a series of numerical experiments select the principle for controlling the operation of the furnace bays ensuring efficient fuel utilization during this period and forecast fuel consumption.

The norming of fuel consumption for a furnace bay being designed (the second group of problems, see Fig. 2) is carried out analogously to forecasting fuel consumption in current production. The difference is only in utilizing consolidated data for the production program in the simulation.

Subsequently, as experimental calculation data are acquired on the specific fuel consumption by heating and heat treating furnaces in processing various type products, it is possible to establish consolidated fuel consumption standards (the third group of problems, see Fig. 2) for utilizing them in design practices and in carrying out evaluation calculations. For this purpose, it is essential to survey the furnace system of machine building plants and on the basis of analyzing the collected information classify each type of furnace design in terms of its technical progressiveness and heat treating conditions while the product range should be classified according to specific fuel consumption. This will make it possible to draw up a rational plan for calculation research and obtain convenient tables and nomograms as a result.

The stated systems approach to norming fuel consumption by furnace bays requires the coordinated execution of a range of projects. A sample network schedule for creating the "fuel" system of a furnace bay is shown in Fig. 4 and this illustrates the sequence of solving the three groups of problems

enumerated in Fig. 2. The first results related to the preparation of production for introducing the "fuel" system can be obtained rather quickly, in approximately 1 year. The first stage of introducing the system into current production can be carried out in 1.5-2 years and the second in 2.5-3 years. These times are basically determined by the significant labor intensiveness of working out the models in the first stage, when their program and information support is created. In the subsequent introduction of these developments for other furnace bays, the introduction times for the stages will basically be determined by the preparation of production and by the correcting of the information support; these can be reduced to 0.5 year and 1 year, respectively.

The realization of the described systems approach to creating and introducing scientifically sound fuel consumption standards for furnace bays will make it possible to substantially raise furnace operating efficiency in the press forging and heat treating shops of machine building plants as well as create a basis for an objective assessment of measures to improve furnace designs and conditions for heat treating of products.

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#### Fuel Consumption Reduction in Heating Metal

Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 11, Nov 82 pp 33-35

[Article by G. G. Nemzer and V. I. Berbenev: "Ways for Reducing Fuel Consumption in Heating Metal in Press Forging Shops"]

[Text] At large machine building enterprises, the press forging shops (PFS) are one of the basic users of fuel consumed in heating ingots prior to forging

and in carrying out the primary (preliminary) heat treating (PHT) of the forgings. The fuel consumption conditions in the heating and heat treating furnaces of the PFS have a complex structure the characteristics of which are determined by a number of production, technical and organizational circumstances and parameters.

By production parameters one understands the operational factors (temperature and length) set by the norms for heating and heat treating. By technical ones one understands the properties of the heating and heat treating furnaces which reflect the degree of their technical advancement. This is characterized, in the first place, by the ability to observe the technologically controllable conditions (rate and equality of heating, temperature accuracy) and secondly by the fuel use factor which takes into account the heat losses in the flue gases, through the furnace's enslosure and leaks and so forth. By organizational factors one understands the existing rules and algorithms for loading and controlling the operation of furnace equipment and here the progressiveness of these can be described quantitatively through furnace utilization factors (for tonnage, time and so forth).

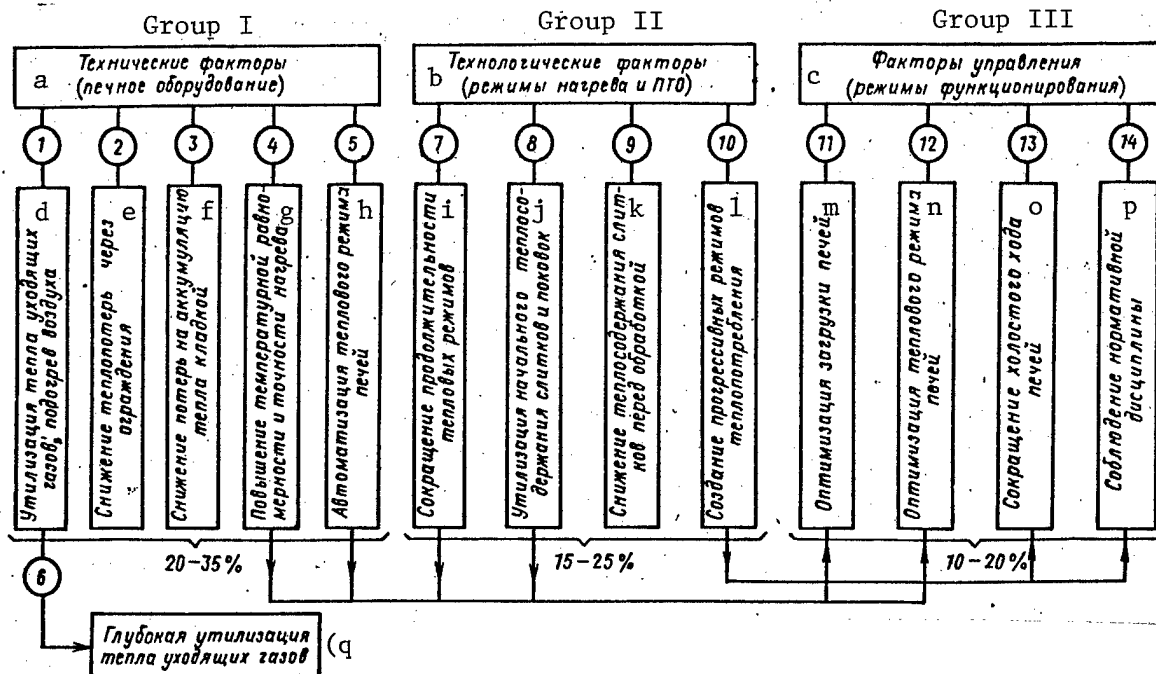
Since the questions of efficient fuel utilization have assumed ever-greater importance in forming the technical and economic production indicators, it is essential to make a thorough analysis for determining the most rational ways for reducing heat consumption in the PFS. The possibilities for reducing the consumption of thermal energy in heating ingots and heat treating of forgings in the PFS will be examined for three conditionally established groups which characterize the structure of fuel consumption.

The diagram [see the following page] shows the structural scheme for increasing the efficiency of heat consumption for heating ingots and PHT of forgings in PFS. For each of the groups their component factors have been given with the indicating of the potential, evaluation contribution of each group to the overall possible reduction in heat use. Many factors from the various groups to one degree or another are interconnected and this necessitates a systems approach to examining the problem as a whole.

The questions of improving furnace design [1] are in Group I which corresponds to the traditional approach.

At present, in terms of periodic-action box furnaces which are the basic type of heating and heat treating equipment in the PFS, there is a rather well elaborated range of technical measures which ensure a significant (by 20-30 percent) reduction in fuel use by the furnaces. These include: increased accuracy, evenness and economy of heating by employing new heating systems and thermal schemes as well as automatic controls; increasing furnace efficiency by recovering the heat from the flue gases (recuperative air heating) and lowering heat losses through the enclosure and in brickwork accumulation by employing new light linings and special devices for sealing the heating chamber.

The carrying out of the given technical measures requires the actual modernizing of the furnace system and significant material outlays. This imposes



Key: a--Technical factors (furnace equipment); b--Production factors (heating and PTO conditions); c--Control factors (operating conditions); d--Recovery of heat from flue gases, air heating; e--Reducing heat losses through enclosure; f--Reducing losses in heat accumulation by brickwork; g--Increasing temperature evenness and accuracy of heating; h--Automation of furnace thermal conditions; i--Reducing length of thermal conditions; j--Utilizing initial heat content of ingots and forging; k--Reducing heat content of ingots before working; l--Creating progressive heat consumption conditions; m--Optimization of furnace load; n--Optimization of furnace thermal conditions; o--Reducing furnace idling; p--Observing norm discipline; q--Efficient recovery of heat from flue gases.

definite limits on the possibility of their complete implementation within acceptable times and makes economically advisable the carrying out of local measures as well (installing recuperators for air heating, replacing the lining in the heating chamber and so forth). However, in creating new PFS and reconstructing existing ones, the entire designated range of technical factors for increasing heat consumption efficiency should be fully utilized. As practice indicates, this does not always occur. At the present stage, the progressiveness of the furnace system should be determined by the degree to which the technical factors for increasing fuel consumption efficiency have been introduced.

In improving and developing new furnace thermal systems by increasing temperature accuracy and heating evenness, prerequisites are created for shortening the length of the individual heat treating stages. This, however, can not always be realized for production circumstances. Nevertheless, in all instances this leads to increased accuracy in carrying out the thermal conditions and this makes it possible to increase the efficiency of the furnace load by better planning and control.

At present, there has been extensive discussion and justification of the need to fully utilize the heat by employing the secondary energy resources. The furnace bays in the PFS from this viewpoint are installations with sufficiently high consumption and temperature characteristics of the heating agent (the flue gases) after the furnaces and this is an additional reserve for better fuel utilization.

In Group II on the structural diagram for increasing the efficiency of heat utilization (see the diagram [on the preceding page]) are the production factors which are determined by two main normed parameters: the duration of the heating conditions and their temperature levels. A shortening of the length of the thermal conditions (primarily by increasing the speed and evenness of heating the ingots and forgings and reducing the high temperature heating time) is, as practice shows, one of the most accessible and effective ways for reducing heat consumption in the PFS. The work [2] has shown that at an absolute majority of domestic enterprises, the conditions for heating ingots before forging exceed the length of already-developed progressive achievements by 30-60 percent. The temperature increase rate and the overall length of the comparable conditions for the PHT of large forgings also differ by 30-60 percent. The incorporation of the progressive Soviet experience existing in this area would reduce specific heat consumption by 12-15 percent in heating ingots (billets) prior to forging and by 8-10 percent for the conditions of PHT. This would be achievable without any substantial expenditures on the current equipment. Improving the thermal conditions of the heating and heat treating furnaces is an important prerequisite which would make it possible to fully realize the given data.

Under the multistage temperature conditions of PHT, the cooling processes are carried out virtually without the use of fuel, but the specific heat consumption also depends upon their execution. Accelerating the cooling conditions and most importantly increasing the accuracy of them make it possible by a more accurate control of the PHT processes over time to better forecast the loading of the heat treating furnaces and more effectively plan the utilization of furnace equipment. Thus, shortening the length of the heating conditions and increasing the accuracy of their execution are a comprehensive factor in fuel savings and the realization of this depends upon the degree of the technical modernity of the furnaces, the corresponding production support for the conditions and the level of control over the thermal processes.

Additional production reserves in saving fuel include the better utilization of the initial heat content of the hot ingots and forgings and reducing the required heat content of the ingots (billets) prior to pressure working. In this sense not only technologically but also energetically progressive are the new production processes which provide for the rather full utilization of the metal's initial heat content (forging of hot ingots delivered to the PFS directly after casting, the quenching of the hot forgings immediately after forging and so forth). The choice of the optimum length of the conditions for keeping the ingots hot prior to heating for forging and the forgings prior to PHT is determined to a significant degree by the conditions for controlling the work of the furnace bays in the PFS and by the procedure for supplying the hot ingots from steel casting production. In the given sense, this category is more an organizational (managerial) one than a production one, however, it must



be pointed out that any shortening of the length of both the transport as well as the conservation operations for the hot ingots and forgings and the reduction of heat losses are an unconditional good from the viewpoint of better utilizing their heat content and saving fuel by this. Consequently, it is essential to introduce reasonable limitations on the duration for performing these operations.

Calculations show that a one-hour increase in the time for moving hot ingots weighing 30-150 tons from steel-casting production to the PFS leads to an increase in specific heat consumption by 30-60 kilojoules per kilogram in the heating furnaces. Additional heat losses may also arise due to the unsatisfactory design of the thermoses in which the hot ingots are transported, as is indicated by the practice of the insufficiently airtight or poorly insulated ones.

In heating the ingots before forging, the temperature factor is manifested in the form of a normatively set heating temperature and the end temperature drop for the cross-section (indirectly through the length of heating at the forging temperature). The production process does not always (not in all forging operations) provide for the necessity of achieving the norm-set maximum temperatures and the high end evenness of metal heating. This creates the prerequisites for a differentiated approach in analyzing the required heat content and temperature distribution in the metal prior to forging. Only when this is technologically possible it must be considered that in a heating temperature interval of 1,150-1,250° C, every 20° C of an increase in the forging temperature requires a 0.5-1 percent increase in the specific heat consumption and in the interval of temperature drops of 30-150° C for the section of the heated ingots (billets), every 20° C of increasing the temperature drop lead to reduced specific heat consumption of 2-5 percent for the specific conditions (the data are given for hot steel ingots weighing 20-100 tons).

Estimate calculations show that the realization of the production group of factors for reducing heat consumption in the PFS makes it possible to achieve a 15-20 percent fuel savings and this can be achieved virtually with minimal expenditures.

As a most important production factor one must also mention the norming and accounting for fuel consumption in heating and heat treating. The absence of scientifically sound heat consumption rates which would differentiate between the technological structure of the heating conditions, the types of charges to be processed in the furnaces and the degree of their technical advancement does not make it possible to create prerequisites for observing normed discipline or encouraging and organizing better fuel utilization. The difficulty of the task is that the individual small-series nature of producing large forgings requires the consideration of a significant number of parameters in creating the heat utilization norms. At present, there is no method making it possible on a modern calculation basis to norm and account for fuel expenditures in the PFS and the creation of this method is a most urgent task.

In Group III of the factors which determine the increased efficiency of fuel consumption are the operating conditions of the furnace equipment. Their influence is very significant and is determined by the efficiency of furnace

utilization. Two types of tasks arise in optimizing the operating conditions of heating and heat treating equipment. In the first is the finding of an optimum plan for the loading of the furnace bay and in the second, the optimizing specifically of the furnace temperature conditions within the carrying out of the established loading plan. The existing methods for planning the load and controlling furnace operation in the PFS do not envisage the use of any mathematical methods or computers and these are the basis of the modern methods for optimizing the thermal conditions and their automatic control. This is a serious impediment in developing progressive heat treating conditions which would make it possible to minimize fuel consumption in the furnaces [4]. The lack of optimization devices and automatic control systems also does not allow the full realization of a large group of technical and production factors shown in the diagram and requiring increased accuracy and more rigid control of the heating conditions. From the example of rolling production one can see substantial accomplishments in achieving economic heating conditions for ingots in pits and this has been achieved by employing modern automatic control devices and computers [3].

As a rule, the PFS employ batch-type periodic furnaces and this causes idle time in operating them. By this, one understands the presence of a heated furnace which is not fully or not at all loaded with metal. The latter is rarely encountered in practice while the holding of the metal at temperature or the accumulation of a batch within which the furnace is idle, as has already been pointed out, is technologically an organizational element of production. The lack of any restrictions in the existing norms for the length of accumulating ingots and forgings and the keeping of them hot as well as the low furnace load factors in a majority of the PFS make it possible to conclude that there are substantial reserves for reducing heat losses by shortening the idle time of the furnaces.

Among the control factors one could obviously also put the observance of norm discipline in the PFS. In and of themselves the norms and instructions can be rather progressive while their realization is unsatisfactory due to the poor organization of production. This applies primarily to the length of heating operations, one of the most essential parameters determining the fuel consumption conditions.

From an examination of the diagram shown in the drawing and the analysis made of the heat consumption structure in the PFS, it is obvious that each of the designated groups (technical, production and control) contains approximately equal potential contribution to the really possible reduction of heat consumption in the PFS (estimated as a whole from 35 to 55 percent). These estimates have been given in terms of a large group of shops equipped with various furnace equipment, but carrying out approximately the same production methods. Heat consumption could be reduced by one-third in the PFS built or reconstructed in the last 10-15 years and by almost 50 percent at a majority of the enterprises. Here it is essential to point out that substantial results can be attained without any capital expenditures, however the questions of efficient fuel utilization do not exist, as a rule, in and of themselves. They are elements of the overall question of the technical reequipping of the heat treating equipment and methods, of improving the quality of the furnace thermal operations, the rational loading of the furnaces, the controlling of the

heating processes and the forming of progressive production conditions. One must particularly emphasize the determining influence on fuel consumption efficiency of the design decisions taken in selecting the composition of furnace equipment in reconstructing existing PFS and creating new ones.

**Conclusions.** 1. The presented estimates (35-55 percent) for a possible reduction in fuel consumption in the heat treating of metal in the PFS show the significant reserves for improving fuel utilization and the necessity of realizing them.

2. The organization of efficient fuel utilization in the PFS is a complex diverse problem the solving of which can best be done on the basis of specific programs which provide for improved technology for furnace equipment and better control methods for the heating conditions. Within the designated range of questions, it is also possible to have individual, particular solutions which provide a substantial reduction in fuel expenditures for ingot heating and heat treating of forgings without significant outlays.

3. For establishing progressive norm discipline and encouraging better fuel utilization in the PFS, it is essential to work out scientifically sound, differentiated standards for fuel consumption which would consider the structure of the production conditions, the types of products to be worked, the technical properties of the furnace equipment and the control methods of its operation.

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## Analysis of Heating Furnace Operations

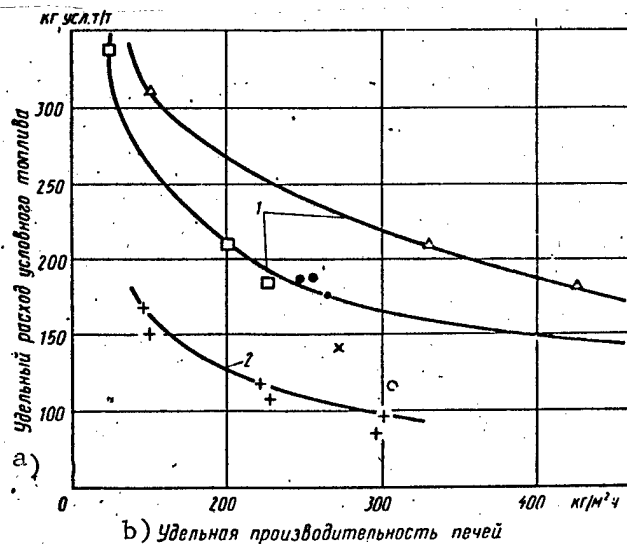
Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 11, Nov 82 pp 36-37

[Article by G. A. Zotov and K. M. Rotnitskiy: "Analysis of Heating Furnace Operations in Press Forging at Machine Building Plants"]

[Text] Efficient fuel use in fired furnaces of the machine building industry has assumed particular significance in light of the Decree of the CPSU Central Committee and USSR Council of Ministers of 30 June 1981 "On Improving Work in the Saving and Rational Use of Fuel and Energy Resources."

A solution to the questions of improving the design of heat treating and heating furnaces and their energy indicators for operation at machine building plants to a significant degree depends upon an analysis of data on the work of existing furnace equipment and the organization of its use.

For a number of years the VNIPITeploproyekt has been studying and conducting heat engineering testing of furnaces built both under the institute's own designs and of other organizations at a number of large machine building plants in the aim of determining actual productivity, specific heat and fuel consumption, efficiency as well as providing recommendations on improving furnace design and bettering the heat engineering indicators. Below are given the results of the survey of the most characteristic periodic heating furnaces (box, double-box and slot-type) which comprise around 50 percent of the furnaces in press forging at the Skopin Auto Parts Plant, the Sterlitamak Machine Tool Building Plant and the Kovrov Plant imeni Degtyarev. The operating lives of the plants vary from 10 years (the Ryazan Plant) to 5 years (the Kovrov Plant).



a--Specific fuel unit consumption;  
b--Specific furnace productivity;  
Δ--Furnaces of the Skopin Auto Parts Plant; ■--Furnaces of the Sterlitamak Plant; ●--Furnaces of the Kovrov Plant imeni Degtyarev; ○--KRN [indirect radiant heating] furnace; X--KRN furnace of Moscow Borets Plant; +--KRN furnace at the Novgorod Plant

Thermal Characteristics of Furnaces with Traditional (1) and Indirect Radiant Heating (2):

The periodic heating furnaces at the designated plants are operated without heat control instruments and systems for proportioning the gas-air ratio.

Thermal engineering testing was carried out during a furnace run (usually 10-12 hours) and here furnace productivity was determined by the productivity of the forging equipment and also the shop plan.

The testing results are given in Table 1.

From Table 1 it follows that the lowest furnace efficiencies of 8.5-8.9 percent and, respectively, the maximum specific fuel consumption of 311-355 kg of fuel units per ton occur in instances of an exceeding of furnace capacity by 30-50 percent in comparison with the productivity established by the press forging equipment and shop program.

In instances of a stricter choice of equipment, furnace productivity also does not reach the designed level due to stoppages related to the resetting of dies, minor repairs and so forth.

A rise in furnace productivity up to 60-85 percent of the designed reduces specific fuel consumption to 200-165 kg of fuel units per ton (see Table 1).

However, in these instances as well, the efficiency of fuel utilization is low as efficiency is from 14 to 16 percent as a consequence of losses from incomplete chemical combustion and reaching 17 percent of the total fuel consumption on metal heating as well as from the lack of recovering heat from the flue gases.

The high heat losses from the incomplete chemical burning, as a rule, are explained by the lack of heat monitoring instruments and automatic temperature controls on the furnaces as well as by the mistaken opinion that the burning of gas with an air consumption coefficient of 0.8-0.9 reduces metal losses from scaling and, in addition, by the tendency to burn the gas in the idling period with an air consumption ratio of 0.7-0.9.

The heat engineering testing showed that the energy indicators (efficiency and specific fuel consumption) in a majority of the furnaces significantly lag behind the level achievable in employing modern gas heating methods before pressure working.

One of the most progressive modern methods for gas heating is indirect radiant heating (KRN) which can be achieved by installing batwing burners in the furnace roof.

The VNIPITeploproyekt has produced standard designs for box, double-box and slot type KRN furnaces with roof burners of the GPP series and designed by the Gas Institute of the Ukrainian Academy of Sciences and VNIPITeploproyekt. These furnaces are already finding wide use in the forging shops of machine building plants.

The institute has investigated various types of such automated periodic KRN furnaces.

Table 1

## Operating Indicators for Periodic Heating Furnaces

1	2	3	4	5	6	7	8	9	10
Печь	Площадь пода печи, м <sup>2</sup>	Температура нагрева металла, °C	Удельная производительность печи, ккал/м <sup>2</sup> ч	Расход тепла на 1 м <sup>2</sup> пода печи, ккал/м <sup>2</sup> ч	Удельный расход тепла на нагрев металла, ккал/кг	Температура нагрева воздуха в рекуператоре, °C	Удельный расход топлива, кг усл. т/т	Коэффициент полезного действия печи, %	Потери тепла от химической неполноты горения, кг усл. т/т
11 Скоринский завод автоагрегатов (проект ВНИПИТеплопроекта)									
a Камерная	0,97	1200	155	337 732	2179	—	311	8,9	34
b Щелевая	1,7	1250	426	540 000	1250	—	181	16,1	31
	2,65	1250	330	484 981	1470	—	210	13,6	39
12 Стерлитамакский завод им. Ленина (проект СО ВНИПИТеплопроекта)									
a Камерная	0,93	1250	225	293 935	1306	—	187	15,4	—
b Двухкамерная	1,92	1250	125	293 125	2345	—	335	8,5	—
	2x1,44	1250	201	295 916	1472	—	210	13,6	—
13 Ковровский завод (проект м/я 840)									
a Камерная	0,47	1220	225	315 957	1239	30	177	15,8	12
b Двухкамерная	2x1,68	1190	204	305 896	1159	60	166	16,4	8
	1,22	1260	252	312 951	1242	100	177	16,2	13

Note. The furnaces of the Sterlitamak Plant are equipped with injection burners with an active gas jet while at the remaining plants the furnaces are equipped with GNP burners.

Key: 1--Furnace; 2--Furnace hearth area, m<sup>2</sup>; 3--Metal heating temperature, °C; 4--Specific furnace productivity, kilocalories per m<sup>2</sup> per hour; 5--Heat consumption per m<sup>2</sup> of furnace hearth, kilocalories per m<sup>2</sup> per hour; 6--Specific heat consumption in metal heating, kilocalories per kg; 7--Air heating temperature in recuperator, °C; 8--Specific consumption of fuel units, kg of fuel units per ton; 9--Furnace efficiency, %; 10--Heat losses from incomplete chemical combustion, kg of fuel units per ton; 11--Skopin Motor Parts Plant (design of VNIPIТеплопроект); 12--Sterlitamak Plant imeni Lenin (design of the Siberian Division of VNIPIТеплопроект); 13--Kovrov Plant (design p/ya840); a--Box; b--Slot type; c--Double-box.

The results of the heat engineering testing of the KRN furnaces are given in Table 2 and in the drawing.

Table 2

Operating Indicators for Furnaces with  
Indirect Radiant Heating of the Metal

1 Печь	2 Площадь пода печи, м <sup>2</sup>	3 Температу- ра нагрева металла, °C	4 Удельная производи- тельность пе- чи, кг/м <sup>2</sup> ч	5 Расход тепла на 1 м <sup>2</sup> пода печи, ккал/м <sup>2</sup> ч	6 Удельный расход тепла на нагрев ме- талла, ккал/кг	7 Температу- ра нагрева воздуха в рекупера- торе, °C	8 Удельный рас- ход услов- ного топлива, кг усл. т/т	9 Тепловой коэф- фициент по- лезного дей- ствия печи, %
Камерная а	1,75	1260	326	266944	801	150	114	24,3
Moscow Borets Plant								
Щелевая б	1,0	1220	270	266960	988	170	141	19,8
Novgorod Plant								
Камерная а	1,74	1200	153	162125	1060	255	151	17,0
»	1,74	1215	224	181808	812	273	116	22,4
»	1,74	1210	299	202025	676	285	97	26,8
Двухкамер- ная	2x1,345	1200	296	181808	614	295	88	30,3
»	2x1,345	1200	227	178932	788	272	112	24,0
»	2x1,345	1200	150	175677	1171	265	167	17,2

Key: 1--Furnace; 2--Furnace hearth area, m<sup>2</sup>; 3--Metal heating temperature, °C; 4--Specific furnace productivity, kg per m<sup>2</sup> per hour; 5--Heat consumption per m<sup>2</sup> of furnace hearth, kilocalories per m<sup>2</sup> per hour; 6--Specific heat consumption for heating metal, kilocalories per kg; 7--Air heating temperature in recuperator, °C; 8--Specific consumption of fuel units, kg of fuel units per ton; 9--Thermal efficiency, %; a--Box; b--Slot-type; c--Double box.

An analysis of the data in Table 2 shows that with a specific productivity of the KRN box furnaces of 300-320 kg per m<sup>2</sup> per hour, specific fuel expenditures on metal heating are reduced to 90-110 kg of fuel units per ton with an efficiency of 25-30 percent characteristic for semicontinuous furnaces. The higher indicators for the thermal work of furnaces at the Novgorod Plant in comparison with the furnace operating indicators at other plants are explained by the fact that furnace productivity at the Novgorod Plant was determined with continuous furnace operation while at the other plants productivity was determined according to the actual production, that is, considering the time spent on loading and unloading the metal. The testing of the KRN furnaces confirmed the correctness of the calculated furnace efficiency set in the plans within the range of 30 percent (see Table 2).

From a comparison of the thermal characteristics (see the drawing, curve 1) for furnaces with traditional heating and KRN (curve 2) constructed from the results of the testing, it is apparent that the specific fuel consumption in the KRN furnaces is approximately 2-fold less than in furnaces with conventional two-headed burners.

Thus, the replacing of the obsolete design periodic furnaces by indirect radiant heating furnaces with GPP and recuperators will provide a fuel savings up to 100 kg of fuel units per ton of heated metal.

With the presence of a large number of obsolete-design furnaces at the plants, the introduction of the modern progressive methods of metal heating will provide a weighty fuel savings in the national economy.

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SIMPLE AUTOMATIC MANIPULATOR FOR SMALL-SERIES STAMPING

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 12, Dec 82  
pp 30-32

[Article by A. A. Kozlov, engineer: "Automatic Manipulator for Stamping"]

[Text] Currently, in spite of the sufficiently high level of development of means of automation, single blanks continue, in a majority of instances, to be stamped using a manual feed. The influx of workers into this type of production is constantly decreasing. The only means of compensating for the shortage of workers and increasing the productivity of blank-stamping production is to comprehensively automate and mechanize it.

We are aware of various means of feeding and automatically removing single blanks in cold and hot stamping, among which are both independent components, automatic manipulators, for example, and mechanisms which are subassemblies of the stamp or press.

The use of automatic and semiautomatic (external-drive) stamps with built-in gate or turret feed are basically suited to the large-series or mass production of small parts.

A number of enterprises use turret feed devices installed on a press which are as a rule designed for one or a maximum of two types of blanks and which have slight potential for modification. These devices are therefore used only in mass production. As they are quite large, these devices make it hard to service the press and considerably narrow the technical potential of the press.

The experience accumulated in introducing type RF-201m, MP-9S, "Tsiklon-36" and other series-produced automatic manipulators (AM) into stamping production has demonstrated their poor economic effectiveness, which results from a number of factors.

First, these AM's must be adapted to specific technological equipment, since, being oriented towards servicing various types of basic equipment, they are not adapted to any one unit, particularly to presses. For example, the "Leningrad Electromechanical Plant" LPO [Leningrad Production Association] uses for loading stamps in its cold-stamping sector RF-201m manipulators modernized so that the complex, expensive "hand" subassembly, with a longitudinal-motion drive, pincer drive and pincer rotation drive, has been replaced by a simple cantilever with an electro-

magnetic tongs. And parts are removed from the stamp by a simple blast of air. Another Leningrad enterprise has also introduced a technological complex based on the RF-201m AM, with the arms also replaced by an original component developed and manufactured at that enterprise. Thus, in addition to expenditures on acquiring a series-produced industrial robot, the average cost of which is 7,000 to 10,000 rubles, additional expenditures arise when it is modernized to meet the technological needs of production.

Second, a whole complex of nonstandard equipment must be developed and manufactured to introduce an AM into production: a loading device, special grippers, pick-ups, additional technological fittings, and to create a technological line based on several AM's -- transfer devices or intermediate positions. All this requires considerable additional expenditures on introducing a series-produced AM.

Third, the series-produced AM's being released by industry with three or four degrees of motion in a "classic" arrangement, although they are multipurpose to an extent in terms of application, are unsuited for stamping since they occupy considerable space, prevent easy access to the press and make it hard to replace or adjust the stamps and to service the presses and the AM's themselves.

Fourth, a majority of the AM's currently being series-produced have average productivities of 8-12 cycles per minute, which is an order of magnitude lower than the productivity of the press and which is roughly equal to that of an experienced stamp operator.

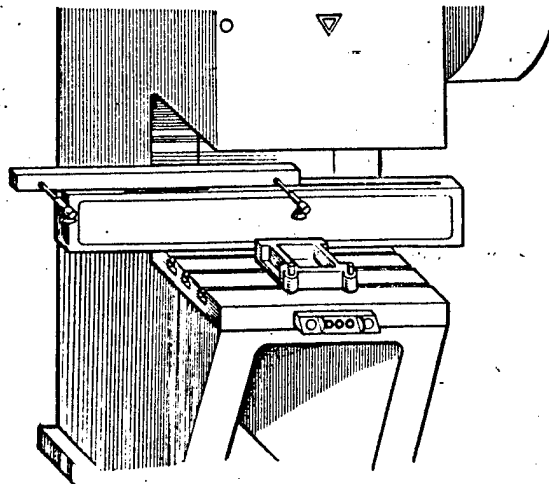
An analysis of the enumerated factors shows that it is most appropriate, for stamping production, to use special, highly productive automatic manipulators with a productivity of 30-40 cycles per minute which are as simple and inexpensive as possible, which do not occupy production space and which are used as a module built into the press.

One example would be the AM RKTБ-7, which is partly built into the press. Its manipulator is located along the rear edge of the press stamp table, with the manipulator drive and control system on a separate stand next to the press. This manipulator, due to its lesser mobility and somewhat simpler design, is very efficient in comparison with a number of other AM's used in stamping, the RF-201m, RF-202m, MP-9s, model 7605 and others, for example. However, even that manipulator, with its separate arm drive is still unnecessarily complex in design, and the stand next to the press not only occupies additional space, but it also definitely makes it harder to service the press and to replace and adjust the stamps and the manipulator itself.

With a view towards increasing productivity and reliability, reducing dimensions, simplifying design and lowering cost, a special stamping manipulator built into a press has been developed and is shown in Figure 1 [top of following page]. Like the RKTБ-7, this manipulator is located along the rear edge of the press stamp table, but it does not have an additional, separate stand. The manipulator air supply and control unit are installed on the side of the press housing. The drawing shows one variant for installing the manipulator, but it can also be installed upside-down, with the arms down, and secured to the press housing uprights at a predetermined distance from the surface of the stamp table. The

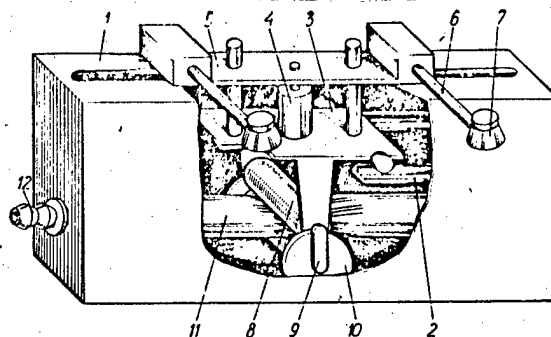
manipulator installation variant is chosen depending on the size of the stamp and the travel of the press, as well as on the shape of the part and the technological features of its manufacture.

Figure 1. Overall View of a Manipulator Installed on a Press



One distinguishing feature of the manipulator being described is its exceptionally simple construction. This has been achieved by installing both arms on one base provided with a two-coordinate drive. The arms move within a 25-35 mm range vertically, driven by an ordinary air cylinder and are powered horizontally by a compressive-type in-line air motor. Tests have shown that this motor, in addition to its simple design, is quite reliable and easy to repair.

Figure 2. Diagram of a Special Stamping Manipulator



It is precisely the use of this compressive air motor which permitted housing the entire operating-unit drive in a small flat space, ensuring small manipulator dimensions, as diagrammed in Figure 2. The manipulator consists of a housing (1) in which a movable carriage (3) is installed on rigid guides (2). The carriage holds the pneumatic cylinder (4) ensuring vertical travel of the base (5) installed on guides in the carriage. Arms (6) with tongs (7) are secured at a prescribed distance from one another on the base. The distance between the arms equals the working travel of the carriage. The compressive-type air motor consists of a pinch roller (8) installed on a fixed axis in the carriage and a movable (swiveling) cantilever (9) with a second spool-shaped pinch roller (10).

An elastic tube (11) whose ends are secured to nipples (12) installed in the end plates of the housing runs between the rollers. The pinch roller (10) must be put in a  $\Pi$ -shaped swiveling cantilever to ensure automatic sealing of the elastic tube pinch zone, which increases the efficiency of the pneumatic motor, and also for rapid, smooth carriage braking by depressurizing the tube pinch zone (in a prescribed carriage travel sector). This is achieved because the distance between the axis of the cantilever attachment to the carriage and the axis of roller (10) is less than the total radii of rollers (8) and (10) and the thickness of the tube walls. Moreover, the manipulator is equipped with a braking device (which depressurizes the tube pinch zone), a device for positioning the carriage in the end positions, and a device for stopping it at a mid-point in its travel (not shown in the drawing). The manipulator can be equipped with either electromagnetic or vacuum-operated clamps. The stamps used with this manipulator must have console-mounted guide columns located near the front side of the press, and the stamp opening zone must be sufficient for the free travel of arms with held blanks and parts.

The manipulator works as follows. In the starting position, the carriage is midway in the housing, so that the arms and clamps are outside the working zone of the stamp. When signaled by the control system, the catch releases the carriage; compressed air is simultaneously fed to one chamber of the tube (the right, for example); the rollers moving along the tube shift the carriage to the outside left position (to the side the loading device is located on). In order to increase the carriage speed, and consequently to increase the productivity of the manipulator, the air leaving the tube chamber exhaust is evacuated more quickly by an ejector installed in the air distributor; it flattens the walls of the tube, ensuring minimal resistance to roller travel. When the carriage approaches the outside position, a protruding resilient stop tips the cantilever to a vertical position; at the same time, a valve connecting the elastic tube exhaust chamber to the outside air shuts in the air distributor. The movement of the cantilever depressurizes the tube pinch zone and a counter-pressure is created in the exhaust chamber, permitting fast, smooth braking of the carriage, which is then secured in the outside position by an electromagnetic latch. In this position, when pressure is supplied to the appropriate pneumatic cylinder chamber, the arms descend and the blank from the loading device and the stamped part from the stamp are grasped. The arms are then raised and the blank and part moved to the far right-hand position. The carriage is braked and secured in this position as in the left-hand position. The arms then drop down and place the blank in the stamp and the finished part in a crate or container; the arms are then raised and the manipulator returns to the starting position. As it approaches that position, the carriage slows and is secured by a protruding latch and the fill chamber of the elastic tube is pressurized. After the manipulator is in the starting position, the control system instructs the press to begin its operating cycle. The positioning accuracy of the manipulator is established by the stops and latches, and pick-ups monitor all working movements. Moreover, the loading device and the stamp are equipped with sensors, so the working movements of the manipulator and the movements of the blanks and parts are monitored.

The manipulator is equipped with a very simple cyclical control system containing an additional emergency subprogram unit in the form of a partial discriminator whose inputs receive signals from the pick-ups and whose outputs are connected to the main program formation unit. This control system structure provides an

opportunity for composing, along with the main working program, additional emergency subprograms enabling the manipulator itself to correct a number of technological malfunctions without operator intervention.

Mock-up study results show that this manipulator can achieve a maximum productivity of 30 cycles per minute, which is ensured by a minimum of operating passes in the cycle and a high speed of travel and fast working-element braking. Moreover, the elastic working chamber of the compressive pneumatic motor was revealed to be highly wear-resistant, making the manipulator sufficiently reliable. This is a consequence of the fact that the wear-resistance of elastic materials to flexing is generally considerably higher than their abrasion resistance, so the wear-resistance of the elastic tube in a horizontal-travel manipulator drive turns out to be higher than the durability of the pneumatic cylinder's packing gland. The simplicity of the manipulator construction ensures its ease of repair. Thus, it is simpler and faster to replace a worn elastic tube fastened to two nipples than to replace the packing gland in a pneumatic cylinder. Reducing the number of operating-cycle passes in the manipulator simplifies, and consequently lowers the cost of the monitoring and control system and enables one to put it in a small housing mounted on the press.

The manipulator described is a special piece of equipment and can be used to feed the stamp flat blanks of practically any size and to remove from the stamp parts with lips no higher than the vertical travel of the arm. Inasmuch as crankshaft presses are currently being released as a normalized series including 10-, 16-, 25- and 40-ton-force presses and others, and inasmuch as each group has standard stamp table type-sizes and a certain working travel, manipulators of the proposed design intended for use with these presses must also be released as a normalized series conforming to press type-sizes. For example, it would be appropriate to make the horizontal movement of the manipulator arms equal to or even a little longer than that of the press stamp table.

Analysis of use of the manipulator described here shows that the economic effectiveness of using this special manipulator is approximately five times higher than that of the MP-9S AM's currently in extensive use due to its lower cost resulting from the considerable simplification of its design and its higher productivity. Whereas technological complexes based on the MP-9S do not recover expenditures on them within the established normative period, calculations show that the recompensation period for this manipulator as part of a complex in large-series production would be 1.2 years, and not more than 1.4 years for small-series production.

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## ROBOTICS

### SM40TS4011 AM MODIFIED FOR MR73-A CENTERING-MILLING MACHINE

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 12, Dec 82  
pp 32-34

[Article by engineer Yu. P. Blinov: "Automatic Manipulator With Numerical Control System"]

[Text] Early in 1982, the "Gomsel'mash" production association (PO) introduced an SM40Ts4011 automatic manipulator (AM) manufactured by the Krasnodarskiy Machine Tool Manufacturing PO. This AM is designed for loading (unloading) parts weighing up to 40 kg onto semiautomatic lathes with a horizontal spindle axis. Due to production necessity, it was necessary to use the manipulator with a semiautomatic MR73 A centering-milling machine. In connection with the design features of the manipulator and the machine tool, as well as with known shortcomings in the control relay circuit, the latter was replaced with a numerical one, permitting successful use of the AM for that type of machine tool and ensuring reliable operation of the complex as a whole.

All AM movements are hydraulically powered on command from the control system. The manipulator hydraulic power supply is also its base. The right side of the power supply contains the hydraulic fluid reservoir and the left contains the pump and the hydraulic devices. The column housing is rigidly fixed to the hydraulic power unit. The column has three adjustable stops. A carriage travels along the column axis on roller bearings. The carriage is moved by a hydraulic cylinder using a rack and pinion mechanism. The carriage travel control slide valves and manipulator arms are located on the column, along with the carriage and arm position sensors. The carriage has two adjustable stops.

The manipulator arm housing is secured to the carriage.

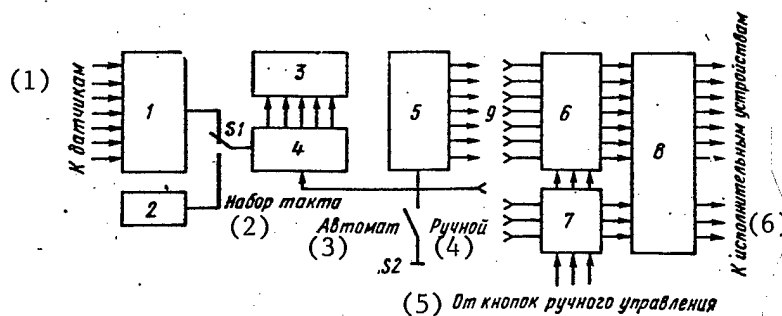
The arms move horizontally using a rack and pinion mechanism. The "wrist" of the arm and the grippers are located on the rear portion of the arm. The wrist can move in a direction transverse to the basic movement of the arm using two hydraulic cylinders located in the wrist housing, which also contains the hydraulic cylinder for closing and opening the gripper and the hydraulic cylinder for rotating the gripper about a horizontal axis (tilting). The horizontal travel of the wrist and the rotation (tilting) of the gripper are done in the outermost positions. A braking slide valve is anticipated for smooth stops.

# Technical Data on an AM With Numerical Control System

number of degrees of mobility	5
number of stops:	
arm rotation	3
other motions	2
positioning precision, in mm	±5
linear arm travel, in mm:	
vertical	750
horizontal	750
greatest angle of rotation, in degrees:	
arm about vertical axis	270
wrist	180
greatest linear wrist travel, in mm	60
greatest speed of column rotation, in degrees/second	60
operation	automatic, preset program; manual, control button
control system element base	integral
number of microcircuits per control system unit	25
program storage device	plug motherboard
maximum number of operating cycles	32
number of instructions to external equipment per cycle	6
number of sensors	13
operating cycle display	binary code
power consumption, in Watts	
manipulator	1,200
control system	3.5

The control system consists of the following main devices: sensor matching device, operating cycle pulse generator, binary operating cycle recorder, operating cycle decoder, operations decoder, decoder for instructions to external equipment, current switches (see drawing).

## Functional Diagram of an Automatic Manipulator Control System



### Key:

1. To sensors
2. Set of operating cycles
3. Automatic
4. Manual
5. From manual control buttons
6. To slaves

The sensors matching device (1) converts the output voltage of the sensors into impulses with a logic-level amplitude and corresponding front durations necessary for operating 155-series microcircuits. The operating cycle pulse generator (2) processes square-wave pulses with a 500-msec succession period and sets the number of the operation needed. The operating cycle recorder (4), a five-digit binary counter, records and stores the number of pulses reaching its input. The operating cycle decoder (5) distributes negative pulses to 32 outputs.

The operating cycle decoder inputs are switched to the outputs of the counter digits and the display device (3), and the outputs of the decoder are switched to the patching panel (9) to program operation of the manipulator. The operations decoder (6) is 18 eight-path "OR" circuits and is designed to detect the needed instructions in a prescribed sequence. The decoder for instructions to external equipment (7) is similar in operation to the operations decoder. The current switches (8) are designed to amplify logic signals to the level necessary for normal operation of the manipulator and equipment (relays, electromagnets, and so on) slaves.

At the start of the cycle, the counter is "zero-set," corresponding to the presence of a signal only at the first operating cycle decoder output. The patching panel sends this signal to the operations decoder and then to a current switch which switches on a slave electromagnet.

The operation is done until a signal is received from a sensor signifying the end of the operation. The sensor pulse adds a unit to the operating cycle recorder and a signal correspondingly appears only at the second operating cycle decoder output. This signal is sent through the patching panel to the operation decoder for another instruction and the servo mechanism for that instruction is turned on through a current switch. Thus, after the manipulator carries out each instruction from the sensors matching device, a pulse appears which changes the state of the operating cycles counter by one. The instructions are consequently carried out in sequence. This circuit permits any sequence of instructions. A decoder of instructions to external equipment is switched in parallel to the operations decoder. This permits close synchronization of manipulator and machine tool operation. Switch S2 interlocks the operating cycle decoder, thus permitting manual control of the manipulator independent of the status of the operating cycles counter.

Switch S1 switches the operating cycle pulse generator to the counter input, enabling the operator to begin the manipulator operating cycle with any instruction.

The outputs of the operating cycle counter digits are switched to the display device, providing an opportunity to monitor the operation of the manipulator and creating additional ease of control.

As an example, here is a program for operating the manipulator with the semi-automatic MR73A centering-milling machine.

Operations done by the manipulator when used with an MR-73 centering-milling machine: 0) arm forward; 1) grippers clamp; 2) carriage up; 3) arm back; 4) rotate towards machine tool; 5) arm forward; 6) wrist withdraw; 7) carriage



down; 8) grippers release; 9) arm back, grip part, machine tool switched on; 10) arm forward, release part; 11) gripper clamp; 12) carriage up; 13) arm back; 14) rotate towards storage unit; 15) carriage down; 16) arm forward; 17) gripper release; 18) arm back; 19) rotate towards feed bin, wrist in.

From the zero through the fourth instructions, the manipulator is unloading the bin and carrying the part to the machine tool. From the fifth through the eighth instructions, it is placing the part in the machine's clamps and orienting it relative to the cutting tools. Through the ninth instruction, the arm is being pulled back and the machine is being instructed to "clamp the part" and then "switch on."

After the machining cycle ends, the manipulator is instructed "end of machining." The tenth instruction, "arm forward" is carried out and the machine tool is instructed "run part." From the 11th through the 19th instructions, the manipulator unloads the machine tool and loads the storage unit. The manipulator is interfaced with the machine tool by switching in corresponding relays to the manipulator current switches. Introducing the manipulator has permitted a reduction in the labor-intensiveness of this operation.

The economic impact has been 700 rubles. Work is currently underway to introduce another four SM40TsI011 AM's and develop an automatic line based on them.

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## ROBOTICS

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### RPG1M COLD DIE FORGING AM DEVELOPED BY ALTAY INSTITUTE

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 12, Dec 82  
pp 34-35

[Article by engineers A. I. Novoselov and G. G. Chernykh: "Specialized Cold Die Forging Automatic Manipulators"]

[Text] It is appropriate to use in cold die forging in tractor and agricultural machinebuilding specialized automatic manipulators (AM) occupying little space and easier to manufacture, adjust and service, meaning cheaper than multi-purpose AM's, to automate cold die forging operations.

A majority of the cold die forging operations do not require a large set of movements or a large number of stops in the operating cycle, enabling one to automate them using comparatively simple AM designs.

The Altay Scientific Research Institute of Machinebuilding Technology (ANITIM) has developed the RPG1M AM, specialized to automate cold die forging operations (Figure 1 [not reproduced for this report]). It is simple in design, occupies little space ( $0.4 \text{ m}^2$ ), has a minimum of scarce assembly components, and is easy to adjust and operate.

This AM is made in a cylindrical system of coordinates, has two arms and makes the following movements: longitudinal independent arm movement forward and backward, joint arm rotation relative to the vertical axis, vertical independent gripper movement on each arm.

Depending on the configuration of the blanks being carried, the AM is equipped with electromagnetic or vacuum-powered grippers.

Pneumatic drive, cyclical control system based on series K511 integrated microcircuits.

The AM has the following features: no programmable vertical arm movement, which considerably simplifies the rotation mechanism design; for grasping blanks, each gripper is installed on a programmable lift mechanism mounted at the end of each arm; there is a manual arm lift drive for setting the arm at the level of the stamp; there is no mechanism for rotating the gripper relative to the arm axis, which simplifies its design (this degree of mobility is unnecessary for a majority

of cold die forging operations); the control system is simple, with only eight programs, which is adequate for cold die forging operations.

#### RPG-1M Technical Specifications

arm load capacity, in kg	5
number of arms	2
coordinate system	cylindrical
degrees of mobility	4
programmable	3
horizontal arm travel, in mm	725
speed of arm travel, in mm/sec	750
vertical arm travel (not programmable), in mm	150
vertical gripper travel, in mm	40
arm rotation relative to vertical axis, in degrees	120
rotation speed, in degrees/sec	90
positioning error, in mm	
arm rotation	±0.5
other coordinates	±0.1
dimensions, in mm	1650 x 570 x 850
weight, in kg	600

The specialized RPG-1M was introduced at the Altay Motor Plant as part of two technological complexes for cold die-forging parts.

The first complex was designed to stamp clutch plates from 380 x 380 and 420 x 420 mm blanks (Figure 2). One stamping operation is required to manufacture these parts. The complex includes a 2,500-kH press (1), the AM (2), a feed bin (4), a container for finished parts (5) and a scrap container (3). The complex operates as follows. The left AM arm loads square blanks from the feed bin onto the press and the right removes from the press scrap generated by stamping the part and discards it into a container. The stamped plates are tossed into a kicker box mounted on the press.

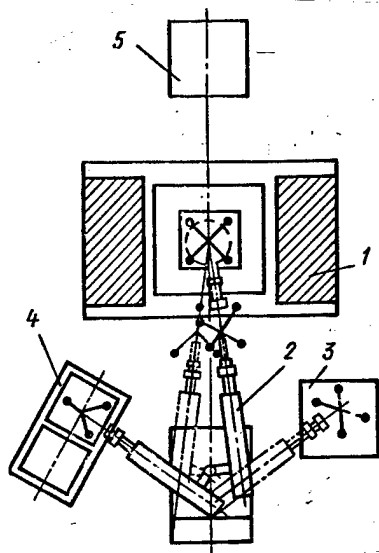


Figure 2. Clutch Plate Stamping Complex

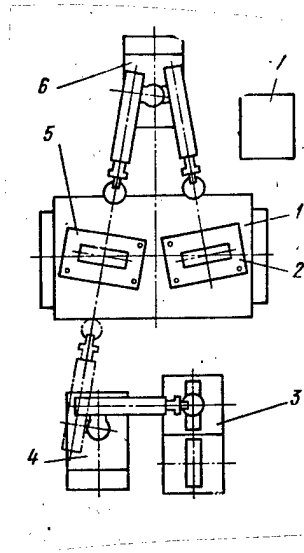


Figure 3. Cover Stamping Complex Based on Two AM's

The second complex is designed to stamp covers from 166 x 570 mm blanks. The complex performs two stamping operations: shallow (30 mm) stamping and straightening. It consists of a double-crankshaft 1,600-kH press (1, Figure 3 [preceding page]) onto which the stamps (2) and (5), a one-arm (4) and two-arm (6) AM, a feed bin (3) and container (7) are installed.

The complex operates from a common control system following a program in which blanks are placed on stamp (5) from the AM feed bin (4). The right AM arm (6) moves the stamped parts to stamp (2), where they are straightened. The left AM arm takes the finished parts from stamp (2) and tosses them into container (7).

Both complexes are interlocked, ensuring accident-free operation.

To automate work on presses when 80-160 mm round blanks are used, the institute developed a complex consisting of a press, an automatic device for loading round blanks onto the press and a device for removing parts from the press by compressed air.

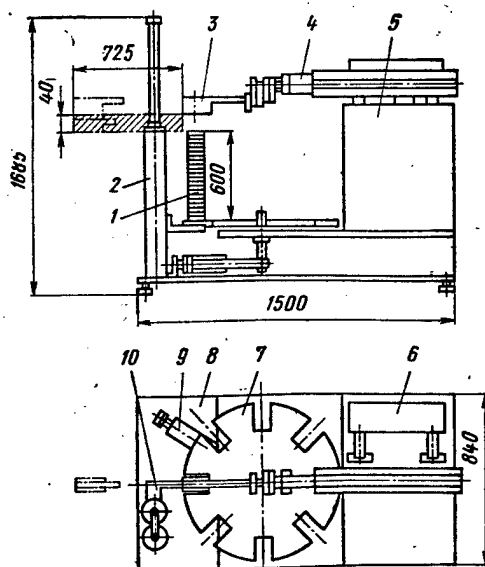


Figure 4. Automatic Device for Loading Round Blanks Onto Presses

The installation (Figure 4) consists of an eight-position rotating feed bin (7) with automatic position shifting during operation, a manipulator (4) with two degrees of mobility, a control cabinet (5) and control board (6). An RPG-1M AM arm was used as the manipulator.

Stacks of round blanks up to 600 mm high are manually loaded into the feed bin compartments. The top blank is fed into the press from the working position of the feed bin (1) by the manipulator electromagnetic gripper. The top level of the stack of blanks is automatically and constantly kept in the operating position, the stack being raised by a pneumatic cylinder (2) connected to a lift platform (10) on which the stack of blanks rests in operating position in the bin. The top level of the blanks is monitored by a contactless pneumatic device

(not shown in the drawing). The bin rotates by pneumatic cylinder (9) to the next position after a blank is used from the preceding compartment.

All other parts of the device are mounted on a common stand (8).

The stamped parts are removed by a push rod installed on the manipulator gripper or are blown off into a container with compressed air.

A fully loaded feed bin will ensure automatic operation of the complex for 2.4 hours with 2-mm thick blanks and for 1.5 hours with 3-mm thick blanks.

#### Technical Specifications

productivity, in units per hour	900
cycle duration, seconds	4
manipulator load capacity, in kg	5
degrees of manipulator mobility	2
gripper travel, in mm:	
horizontal	725
vertical	40
positioning error, in mm	±0.5
number of bin positions	8
diameter of blanks being fed in, in mm	80-160
air pressure in line, in MPa	0.4-0.6
dimensions (length x width x height), in mm	1500 x 840 x 1685
weight, in kg	460

Use of the complex for stamping four type-sizes of plates enabled us to raise productivity, free workers from monotonous manual labor and ensure work safety.

The institute developed the RZP-1 AM (Figure 5 [not reproduced for this report]) to service closed-type presses 1,600 kH and larger.

The AM was made in a rectangular system of coordinates. Two arms were mounted on a common base; each has independent mechanisms for moving grippers vertically and horizontally. The arms are moved along the base by an electromechanical drive installed on one of the arms.

The main features of the RZP-1 are: considerable horizontal arm travel (up to 1,600 mm), electromechanical drives based on series asynchronous motors, telescoping arms with double cables, which considerably reduces the production space occupied by the AM.

#### Technical Specifications

load capacity of the arm, in kg	25
number of arms	2
number of programmable movements	5
arm travel, in mm:	
horizontal	1,600
vertical	300
transverse manipulator travel, in mm	2,000
power consumed, in kW	5.2

[RZP-1 technical specifications, continued]

positioning error, in mm	±1.0
maximum size of blanks being loaded, in mm	800 x 800
drive	electromechanical
control system	cyclical
dimensions, in mm	5900 x 1500 x 1400
weight, in kg	2,120

The Altay Tractor Plant used the RZP-1 AM as the base for a complex to stamp large-sized parts.

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